Lecture Notes in Educational Technology

Ronghuai Huang · Dejian Liu ·
Michael Agyemang Adarkwah ·
Huanhuan Wang ·
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Envisioning the Future of Education Through Design

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Preface

In 2021, *The International Commission on the Futures of Education* mentioned that the survival of humanity, human rights, and the living planet are at grave risk. As a foundation in the transformation of human societies, education is also in a deep crisis, including poor education quality, inequitable expansion of education, digital divide, challenges encountered by teachers, etc. During the *Transforming Education Summit* in September 2022, António Guterres, UN Secretary-General, stated that education is fast becoming a great divider instead of being a great enabler. Also, the new round of scientific and technological revolution has a trend of integration with educational transformation, posing new challenges to the futures of education. To solve the existential educational crisis and adapt to the learning needs in the new era, it is imperative for researchers, educators, and policymakers in education to devise more practical and effective innovations and reforms to safeguard the futures of education—seek new breakthroughs in educational design.

Design thinking is beneficial to helping us look beyond the present and into the future, the reality, and the constraints, for appropriate educational solutions. In particular, pioneered in the 1990s, value-sensitive design (VSD) provides theory and method to account for human values in a principled and systematic manner throughout the design process. From a different design perspective, the process of VSD enables designers to conduct analyses of direct and indirect stakeholders; distinguish among designer values, values explicitly supported by the technology, and stakeholder values; consider individual, group, and societal levels of analysis, etc. The concepts of design thinking and VSD align with the needs of future talent training. Therefore, pedagogical approaches, lessons, curricula, and educational systems must be deliberately designed. The outcome of educational design could be classified into five main categories: product design, solution design, service design, mechanism design, and policy design.

Early in 2015, we realized that design thinking could strategically help students generate and test solutions to a problem or drive a project forward at an inflection point in the education sector. We have been conducting research on cyberlearning development, especially the Design Methodology by Dr. Liu Dejian. Also, Smart Learning Institute of Beijing Normal University is at the forefront of advancing educational technology and related fields, with its the establishment of Design & Learning Laboratory, which specializes in research on design thinking in the youth, exploration of characteristics of innovative thinking, development of curricula and textbooks, and discussion on approaches of transforming education through design with well-known universities and institutes worldwide.

In 2016, we visited the renowned d.School at Stanford University and cooperated with Prof. Larry Leifer, in charge of the 40-year-old ME310 course. Sponsored by NetDragon, Beijing Normal University recruited outstanding postgraduates and PhD fellows to conduct a nine-month ME310 course online and offline with students from Stanford University. With a theme of "Future Classroom", students designed the project TEAMO—a robot prototype supporting group learning.

In 2017, Mr. Liu Dejian was invited to teach the course "Next Generation Design: Methods and Heuristics" to students from Harvard Graduate School of Education. More than 50 postgraduates participated in the course. Students developed a kind of interactive product with a theme of game design based on Design Methodology, including original analysis, user analysis, stakeholder analysis, scenario analysis, competitor analysis, and function list.

Inspired by the cooperation with Stanford University and Harvard University, we initiated a course titled "Design and Learning" at Beijing Normal University in September 2017, which was offered as an elective for over 30 postgraduates. In 2018, employing a synchronized approach with 10 domestic universities, nearly 50 postgraduates were engaged in the learning process. The course employed a flexible learning framework, combining "online livestreaming" with "on-site guidance," catering to personalized learning needs and extending the educational experience beyond the confines of the traditional classroom setting. Meanwhile, in 2018, we managed to organize a "48H Finals on Education Design" competition. The competition featured the themes of family education, science education, and safety education, with 60 students from various backgrounds in China. Until now, the competition has experienced consistent growth over six years, both in terms of participation scale and the diversity of subjects covered. This competition addresses tangible challenges in education, such as rural education, inclusive learning, and artificial intelligence in education, attracting teachers and students from various backgrounds. It has yielded impressive participation numbers: over 4,000 students with 400 educational projects and more than 2,500 teachers contributing to over 700 case studies.

In 2020, the COVID-19 pandemic revealed unprecedented challenges to education where over one billion students had to learn online. Confronted with the uncertainties of the future, design thinking for innovation is one of the core competencies that students should acquire to face these uncertainties. During this period, by analyzing the characteristics of online education, we put forward the concept of flexible learning and completed a series of guidance handbooks, helping teachers better organize online classes and students better conduct active learning.

Based on these experiences, the "Design and Learning" course has become more mature with flexible forms and abundant projects. Under the guidance of a mentor team composed of university and enterprise experts, students participating in the course and competition have completed over 200 future-oriented educational solutions, some of which have been applied for patents and software copyrights. Through the course, students have understood the characteristics of futures of education, the process and methods of design thinking, and the expertise of software design, user experience, AI, etc. The "Design and Learning" course has brought five major changes to traditional classrooms, namely, breaking the spatial boundaries of classrooms, constructing diversified teaching space-time, promoting the symbiotic teacher-student relationship, adding rich and flexible teaching interaction, and changing the mode of knowledge production from being passive to active.

Nowadays, the annual "Design and Learning" course and Global Competition on Design for Future Education have become regular initiatives for Smart Learning Institute of Beijing Normal University. It is expected that, through the course and competition, we can cultivate the educational design capability of senior undergraduates and postgraduates in educational technology, science education and related majors, helping them master the connotation, methods and means of innovative design in the field of education, designing technologies and products that can adapt to specific scenarios and conform to the laws of education, and exploring design-based learning in human-computer collaboration.

As a compilation, this book aims to assist educators and various stakeholders (e.g., administrators, practitioners, researchers, teachers, and students) in the educational field to realize the importance of design in education and encourage them to use design and design thinking to solve educational problems and issues. Part I presents an overview of opportunities and challenges for the futures of education. Part II illustrates the emerging models of design tinking for education. Part III presents the typical scenarios and approaches of design in education by formulating a set of outcomes of educational design and providing best practices for implementing the application of design in education. Part III is comprised of learning activity design, educational design for learning with special needs, designing learning spaces of the future, designing the classroom of the future, the design of authentic learning, the design of elderly education, etc.

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Part I
Futures of Education: Opportunities and Challenges

Chapter 1
New Trends of Digital and Intelligent Technology

Michael Agyemang Adarkwah

Abstract Technological advancements have dramatically changed the status quo of education. Many educational institutions use cutting-edge and innovative technologies to provide education for learners inside and outside the school learning environment. The premise is that technology will lead to better outcomes and provide solutions to educational and societal problems such as reducing teaching workload and administrative tasks and facilitating distributed learning and workplace productivity. Consequently, the trend of world education now is transferable skills or twenty-first-century skills facilitated by advanced forms of technology. However, many classrooms today in many educational institutions still remain unchanged, are still predominantly curtailed by didactic methods, and are reluctant to infuse technology into teaching and learning. Additionally, in many education systems that have embraced technology-enhanced learning, technology is not properly designed for users. Technology has become a "great divider" instead of a "great enabler." The current situation threatens the achievement of the United Nations' (UN) Sustainable Development Goal which emphasizes inclusive and equitable quality education. The use of technology in education should comply with learner-centered approaches to yield a positive learning experience for students. It is proposed that the application of design learning approaches in modern education which is powered by technology will provide support to educators, teachers, and learners in the utilization of digital technology in the rapidly evolving landscape of teaching and learning.

1.1 Development Trends

The Sustainable Development Goals (SDGs) hope to transform the world by making a global call to action to ensure sustainable, resilient, and peaceful futures for our planet. SDG 4 which focuses on education aims to use education as a catalyst for sustainable development of nations by ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all people (UNESCO, 2019).

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Thus, education seeks to find an effective solution for the complex problems of our world (Burbules et al., 2020). According to Burbules and colleagues, the complexity of our modern world has been heightened as a result of the digital transformation of the global economy and the rapid change experienced worldwide due to connectivity. Hence, making the need to investigate how education can be linked to the development trends of our society to address emerging challenges (such as employment, poverty, gender equality, health, peace and security, human rights, urbanization, population, etc.). Shi et al. (2022) add that it is impossible to separate the development in society from talent, making it necessary to cultivate talent in education through the effective design of the teaching and learning process.

Education yields positive and social return rates in both developed and developing countries (Thapa et al., 2020), enhances the competency of an individual for employment, promotes better health, has the power to eradicate poverty, and improves the quality of life (UNESCO, 2016). Globally, education is recognized as one of the indicators of the Human Development Index (HDI), which is an integral aspect of the sustainable development assessment (Burbules et al., 2020). Although the United Nations Educational, Scientific and Cultural Organization (UNESCO) considers education a key society priority, there are many educational issues that are still unresolved (Castro, 2019). That is, education today is faced with myriad challenges. Castro (2019) tags education as a "complex system" that needs to be carefully analyzed and designed. A form of education that is skill-based and lifelong in nature is highly valued in our contemporary society because of its ability to keep learners on par with recent development in the world.

As a result, the trend of world education now is transferable skills or twenty-first-century skills (Burbules et al., 2020). Traditional forms of learning are being replaced with technological learning to transform the educational experience for the sustainable growth of the economy. The demand in work-based and school settings has prompted the need to incorporate digital technology into teaching and learning for greater efficiency. Technology is acknowledged as a facilitator of educational access, inclusion, and equality (Castro, 2019). Educators and designers are constantly exploring ways to build the digital skills of learners to make them prepared for the employment market which operates and thrives on technology-based methods. Some of the current trends in technology education include social media learning, electronic (e)-learning, distance education, smart learning, massive open online courses (MOOCs), open educational resources (OER), etc.

Technological advancements have dramatically changed the status quo of education (Burbules et al., 2020; Chen et al., 2020). Many educational institutions use cutting-edge and innovative technologies to provide education for learners inside and outside the school learning environment. Consistently researching design options for technology-enhanced education has never been more urgent than in this era where there is the ubiquitous use of technology for educational purposes. A well-designed technology-enhanced learning environment promotes flexibility, personalization, collaboration, and academic and social engagement (Gros & García-Peñalvo, 2016). Gros and García-Peñalvo add that there is an improvement in learning retention and work performance when teaching content or courses powered by technology are well-designed. The design of learning content and classroom should be geared toward equipping learners with creative and authentic problem-solving skills and high-order thinking or strategic thinking capabilities.

The concept of design is at the heart of human progress and all humans at a practical level are engaged in some level of design (Kimbell & Stables, 2007). Design and designerly thinking are linked and have a great potential for optimal learning. A design approach to education provides new perspectives on addressing the failure of education systems and different learning models for talent development. Thus, the rapid changes and multitudinous challenges which persist in our world today have called for the need to examine education from a design perspective. Oftentimes, the workforce today in varying contexts lacks the requisite skills needed in their working environment for higher productivity. According to the OECD (2022), examining the future of education in the context of major economic, political, social, and technological trends is essential for educators and designers to support learners. The development trends in education target accessibility, suitability, effectiveness, and innovation. This is to ensure learners of different age groups and from diverse backgrounds acquire skills to help them compete globally and provide authentic solutions to the complex problems of modern society. It is advanced in this book that design-based learning methods of instructional design will promote sustainable development, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UNESCO, 2014, p. 20).

1.2 New Advances in Technology

The advent of the Fourth Industrial Revolution (4IR) has accelerated the permeation of technology into all sectors of society including education. Education is rapidly undergoing a digital transformation or "technologization" as a result of several factors such as the affordance of digital technologies (Xiao, 2019). The newest technologies include virtual reality (VR), augmented reality (AR), Big Data, the Internet of Things (IoT), blockchain, artificial intelligence (AI), etc. Since the latter part of 2022, the growth of artificial intelligence (AI) tools has gained a new impetus with the introduction of ChatGPT (Generative Pre-trained Transformer) by OpenAI. ChatGPT and other large language models (LLMS) are advanced forms of natural language processing (NLP) that are able to generate human-like text, admit mistakes, reject inappropriate requests, and able to complete other educational-related tasks with high accuracy (Adarkwah et al., 2023; Kasneci et al., 2023; Tlili et al., 2023). Many teachers, students, and researchers are making use of advanced AI tools such as chatbots for educational tasks. We are currently in the Education 4.0 era which calls for the infusion of technology in educational institutions to promote personalized and adaptive learning.

Today, the technology used in education can be seen in the form of online learning, mobile applications, massive open online courses (MOOCs), gamification, web

2.0 learning, robotics, online books, programming, student response system (SRS), blended learning, learning management systems (LMS), etc. (Lai & Bower, 2019). The use of technology in education can be witnessed across all school levels from preschool to universities and even in informal settings (Vlachogianni & Tselios, 2021). The premise is that technology will lead to better outcomes and provide solutions to educational and societal problems such as reducing teaching workload and administrative tasks and enabling distributed learning. Another motivation for the use of technology in education is its improvement in access to learning and increasing the motivation of learners (Lai & Bower, 2019).

Also, the skills and manpower requirements in the employment market are frequently undergoing change and it is difficult to keep up with them (Alam et al., 2020). Hence, there is a mismatch between education and many industries. Learners need to acquire the skills for the jobs the 4IR is generating (Ilori & Ajagunna, 2020; Oke & Fernandes, 2020). Students who would be entering the labor field should look beyond the conduct of manual jobs and develop the skill to innovate, adapt, communicate, and solve complex problems (Binkley et al., 2012). According to Binkley and colleagues, there are a vast array of vacant jobs because people with the requisite skills for them are unavailable. That is, there is a need for upskilling and continual lifelong learning for individuals seeking to advance in their careers.

Moreover, the need for a labor force equipped with twenty-first-century skills has propelled the construction of technology-enhanced learning (TEL) environments. TEL environments are “technology-based learning and instructional systems through which students acquire skills or knowledge, usually with the help of teachers or facilitators, learning support tools, and technological resources” (Wang & Hannafin, 2005, p. 5). TEL environments are known for their potential to liberate teachers from bureaucratic duties and daunting administrative tasks through the use of AI techniques (Yusuf et al., 2020).

The integration of technology into education does not come with only benefits but also challenges relating to teaching, curriculum development, research, and government policies (Ilori & Ajagunna, 2020). The education system in many countries is still predominantly curtailed by didactic methods and is reluctant to infuse technology into teaching and learning (Oke & Fernandes, 2020). Classrooms today in many educational institutions still remain unchanged before the inception of the 4IR and when traditional tools and methods were used for work (Ilori & Ajagunna, 2020). It can be perceived that the advancement of technology has made the design of TEL even more challenging than before (Spector, 2000). The use of technology in education which is mostly computer and electronic materials should comply with learner-centered approaches to yield a positive learning experience for students (Oke & Fernandes, 2020).

A properly designed education is the key to unlocking the prospects of the 4IR and addressing the complex challenges facing education and the world today (Ilori & Ajagunna, 2020). One way to do this is through a participatory design (Mor & Winters, 2007) which involves teachers in the design of TEL environments because of their rich knowledge of technology in education (Cober et al., 2015). Teachers often find themselves in a situation where they have to adapt to TEL materials, helping them to cultivate a professional identity of teacher-as-designer helps in constructing the components of design for effective learning (Svihla et al., 2015). Both governments and professional bodies have reiterated the need for teachers to develop the skill of integrating technology in the design of school curricula in order to create personalized and authentic learning experiences for students (Nguyen & Bower, 2018).

Design learning techniques will facilitate the reinvention of education for the greater good by building creative and innovative talents. Design is essential for the successful development of interactive learning environments and aims to support the learner to achieve insight into a specific subject in the TEL (Mor & Winters, 2007). There is a demand for modern-day students to design, share, create, and manufacture complex cultural artifacts by making use of digital technologies (Seitamaa-Hakkarainen et al., 2010). This chapter proposes the application of design learning strategies in modern education which is powered by technology. It has been underscored that design-based research and methods guide theory development, improve instructional design, and create avenues for more design possibilities in a TEL environment (Wang & Hannafin, 2005). Learning design aims to provide support to both educators and teachers in the application of digital technology for effective teaching in TEL environments (Bower & Vlachopoulos, 2018).

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Chapter 2
Challenges in Education During Digital Transformation

Huanhuan Wang and Xixian Zhu

Abstract Education is considered as the pulse of society and one of the most powerful tools for transforming a nation. In an ever-evolving world, it is perceived that education is one of the highly effective approaches for promoting sustainable development and has consistently been demonstrated as a great force for positive change within societies. With the tremendous changes, particularly under the context of the development of intelligent technologies and digital transformation, unpredictability, complexity, and insecurity of our current world, it is imperative to consider whether education can continue as usual. There is concrete evidence indicating that educators frequently face inextricable challenges that hinder the progress towards achieving Sustainable Development Goals (SDGs), particularly SDG4, which aims to promote quality, equity, and equality in education. Thus, it is necessary to understand the challenges in education, so that we can know the critical parts to work on when reforming education during digital transformation.

2.1 The Consensual Challenges of Global Education in the Last Decades

2.1.1 The Generic Issues of Societies Reflected in UNESCO's Reports on Education

One critical mission of education is to prepare individuals and communities to adapt to an uncertain world and intricate future. Therefore, it is necessary to understand this world by identifying the grand issues and challenges for the world. UNESCO's reports, namely "Learning to be: The world of education today and tomorrow" (1972), "Learning: The treasure within" (1996), and "Rethinking Education: Towards a global common good" (2015), offer valuable insights into educational progress

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worldwide. Revisiting these reports is essential for identifying the critical challenges and issues that impact education on a global scale.

The report, "*Learning to be: The world of education today and tomorrow"* (1972), figured out the gaps between developing countries and developed countries, the environment in peril, and threats related to iniquity, alienation, and tyrannies. This report indicated that the scientific-technological revolution of the twentieth century significantly transformed both the physical and cognitive aspects of our world. The evolution of production techniques and economic progress have, in turn, facilitated progress in education. Education has been instrumental in stimulating social and political development, as well as driving technical and economic growth. The scientific-technological revolution ushered humanity into an era of the learning society. The aim of education is to enable individuals to discover their true selves. Rather than devoting solely to the dissemination and storage of knowledge, education should prioritize equipping learners with the necessary tools to acquire knowledge independently and emphasizing the concept of learning to learn. Instead of solely preparing learners for a specific and lifetime profession throughout their lives, the primary objective of education should be to help learners optimize mobility among multiple professions and motivate them for continuous learning and self-improvement. Educational actions must lay stress on "scientific humanism" and "technology". Moreover, strong support must be given to democracy as it has become an impressive concern. This report proposed two fundamental and influential ideas, namely "lifelong education" and the "learning society". To address the challenges in education, the adoption of new technologies, international solidarity, and global cooperation were proposed as indispensable methods.

As time went by, the previous issues discussed in the report, "*Learning: The treasure within" (1996),* were diversified and extended into seven tensions due to changing global circumstances. Identified seven tensions include the tension between the global and the local, the tension between the universal and the individual, the tension between tradition and modernity, the tension between long-term and short-term considerations, the tension between competition and the equality of opportunities, the tension between the expansion of knowledge and human being's capability to assimilate it, and the tension between the spiritual and the material. It is important to notice that this report highly valued the role of education and lifelong learning in building our common future. Education is at the center of personal and community development, aiming to empower learners to develop all their full potential and realize creative aspirations so that learners can take responsibility for their own lives and gain achievements of their personal aims. Additionally, the report emphasized that learning is the heart beat of society. It proposed the concept of four pillars of education. The first pillar, "learning to know", necessitated a combination of broad general education and in-depth work on a selected number of subjects, as societies grapple with rapid scientific advancements and new economic and social activities; the general background serves as the passport to lifelong learning. Second, "learning to do". The acquisition of competencies can support learners to do a job and deal with a variety of unforeseeable circumstances constituting the second pillar, named "learning to do". The third pillar emphasized the importance of "learning to live together" and "learning to live with others". It is necessary to develop an understanding of others and cultural background, create a new spirit guided by the recognition of growing interdependence and a common analysis of the risks and challenges of the future, and induce people to work on common projects and manage the inevitable conflicts in a wise and peaceful way. Finally, the fourth pillar is "learning to be", inherited from the report "*Learning to be: The world of education today and tomorrow*". It calls for everyone to cultivate greater independence, judgment, and personal responsibility in pursuing common goals. Overall, the report stressed the need to tap into the hidden talents treasured in every individual, encompassing memory, reasoning, imagination, physical ability, aesthetic sense, and more.

These challenges and tensions were further updated and elucidated in the report titled "*Rethinking Education: Towards a global common good*" (2015): (1) ecological stress and unsustainable patterns of economic production and consumption; (2) greater wealth but rising vulnerability and growing inequalities; (3) growing interconnectedness, but rising intolerance and violence; (4) progress and challenges related to human rights; (5) the challenges of climate change and promoting alternative energy sources. The report also pointed out the emerging cyber world and its associated opportunities and concerns, the advancements in the field of neurosciences and their potential implications on education, as well as the new trends in creativity and cultural innovation among the youth. To address these multifaceted challenges, this report reaffirmed a humanistic and holistic approach to development, which stands in opposition to violence, intolerance, discrimination, and exclusion. It suggested moving beyond the confines of narrow utilitarianism and economism. Moreover, this report particularly emphasized the inclusion of people such as women and girls, indigenous people, and those with disabilities, who often face discrimination. More importantly, it underscored the need for an open and flexible approach to lifelong and life-wide learning, with the goal being to provide every individual with the opportunity to realize their full potential in order to build a sustainable future and lead a life of dignity. Furthermore, the report implied the creation, acquisition, validation, and use of knowledge are all common to all people as part of a collective societal endeavor. Therefore, knowledge is recognized as the common heritage of humanity, and education and knowledge are reconceptualized as global common goods. This necessitates a shift away from the prevailing utilitarian conceptions of education towards a conception of education as a common good. Lastly, this report recognized the diversity of lived realities while underscoring a common core of universal values. Consequently, more inclusive education should be ensured. Education is critical to developing the capabilities required to broaden the opportunities necessary for individuals to lead meaningful lives characterized by equal dignity.

2.1.2 Responses of the Above Issues from Academics and Practitioners

This series of UNESCO reports initiated a broad discussion on the grand challenges and corresponding solutions, prompting responses from a variety of academics and practitioners, either directly or indirectly. One group of respondents further extended upon these challenges. The Millennium Project (2020) has been examining the 15 global challenges since 1996, which includes sustainable development and climate change, clean water, population and resources, democratization, global foresight and decision-making, global convergence of IT, rich and poor gap, health issues, education and learning, peace and conflicts, the status of women, transnational organized crime, energy, and global ethics. The United Nations (2020) highlighted 22 themes of global issues related to Africa, Aging, AIDS, Atomic Energy, big data for the SDGs, children, climate change, decolonization, democracy, poverty, food, gender equality, health, human rights, international laws and justices, migration, oceans, peace and security, population, refugees, water and youth. Some groups of researchers further provided supportive evidence for specific challenges. For example, Roser (2020) presented evidence of increasing inequality between regions and generations globally and its implications for health, education, and income. Other groups focused on the challenges in specific areas and further provided solutions. Bell et al. (2009) serve as a good example, as they emphasized the rapid proliferation of digital data and the resulting challenges in data management, curation, and archiving. They suggested that a data-intensive science and computing system architecture can be helpful. In sum, the relationship among these works indicates the possibility of coming up with the consensual challenges.

2.1.3 The Key Challenges the World Facing in the Long Term

Based on a selection of research reports and academic studies, we analyzed the main themes regarding the challenges in a thematical way. This process involved carefully reading through each literature source, extracting the major underlying themes, and then aggregating and re-structuring them. The consensual challenges of education, which were selected based on their significant impact in the long run, are presented below. Some of the inputs for this selection were obtained from a workshop organized by the research team. Each challenge is explained below.

- **The extraordinary expansion of data, information, knowledge, and human being's limited capability to process it**. UNESCO's (1999) report highlighted concerns regarding the expansion of knowledge, new subjects to study, and the subsequent pressure on curricula. The expansion goes beyond the field of education, as an exponential growth of data and information presents challenges for humans to process the generic work involving management, analysis, archiving, and curation of the data (Bell et al., 2009).

- **Global economic disequilibrium and social inequalities**. Despite economic growth, the gaps among countries and regions have continued to widen over the past two centuries (UNESCO, 2015). This economic disequilibrium observed both in developed and developing countries, leads to inequalities in terms of health, education, income, opportunities for development, and so on (Roser, 2020). Those in disadvantaged situations, particularly individuals with special needs, face even greater challenges in accessing resources.
- **Rising competition and vulnerable employment**. The growth of GDP does not necessarily generate corresponding employment opportunities and levels (UNESCO, 2015). In fact, automation technology and digital transformation may have the potential to diminish job opportunities, further exacerbating the vulnerability of employment. The upcoming changes and uncertainty surrounding future job prospects, driven by the increasing adoption of robotics, AI technologies, as well as changes in the workplace dynamics through collaborative, team-based, and virtual reality techniques, contribute to the heightened vulnerability of employment (Schwartz et al., 2019).
- **Growing interconnectedness, but rising intolerance, exclusivism, and violence**. The proliferation of cybertechnologies and mobile devices has facilitated greater interconnectedness among individuals. However, this growing connectivity has coincided with the emergence of exclusivist worldview, cultural intolerance, armed conflicts, drug production, and even violence (UNESCO, 2015). Meanwhile, one can anticipate an escalation in information warfare, cyber-attacks, and organized crime (The Millennium Project, 2020).
- **Social diversity and fragmentation**. The advent of social media and cyber technologies have set up more platforms for diverse public expressions, leading to more salient cultural diversity that can positively contribute to innovation and sustainable human development (UNESCO, 2015). However, this progress is accompanied by the observed fragmentation in political systems (Witzig & Vatter, 2018), social systems (Chakravarty & Fonseca, 2014), religion system, and so on. As a result, addressing the diverse needs and individual characteristics poses a significant challenge.
- **Threats to democracy and human rights**. Although we have achieved great progress in the protection of human rights, challenges persist due to the influence of powers and interest groups. Ensuring universal democracy and upholding human rights through laws and ethical norms remains a formidable task (UNESCO, 2015). This challenge is particularly pronounced in countries marked by internal and external conflicts and where the institutional protections of human rights are either insufficient or non-existent.
- **Pressures related to the environment, ecology, and natural resources**. Economic growth plays a crucial role in enhancing human well-being. However, unsustainable patterns of development characterized by uncontrolled growth and overexploitation have led to adverse consequences. These destructive outcomes, such as climate changes, natural disasters, degradation of vital natural resources, loss of biodiversity, spreading of contagious diseases, pose significant risks to

humans, especially those residing in impoverished regions (UNESCO, 2015; Xi, 2017).

- **Globalization, local demands, and conflicts**. As individuals with distinct backgrounds, identities, and cultures get more involved in the waves of globalization, they are becoming global citizens. However, this occurs amidst the rise of economic nationalism and even policy threats that challenge this notion. At the same time, their local communities still demand them to take active roles in addressing local issues. Balancing these diverse demands, including the choice of guiding principles, adaption to cultural styles and behavioral norms, and collaboration with different groups, proves to be a challenging task. This challenge is not limited to the present times but has been acknowledged in the past (UNESCO, 1996) or and remains pertinent in contemporary society (Ghemawat & Altman, 2019).
- **Limitations of material progress and cultivation of the spiritual world**. While placing emphasis on economic has undoubtedly yielded material progress, it has also revealed its inherent limitations (UNESCO, 1996). Conflicts can take place when material and spiritual aspects of life are perceived as separate or mutually exclusive. Human's well-being can suffer when materialistic values and goals, such as the accumulation of wealth, possessions, image, and status relative to others, are prioritized (Kasser, 2018), which leads to the need to nurture the spiritual dimension of humans' existence encompassing ethic, culture, critical thinking, and other aspects.
- **Long-term and short-term considerations in decision-making**. Previously identified in UNESCO's report (1996), this tension of decision-making processes in addressing significant problems becomes apparent when public opinions request immediate solutions, while the complexity of these problems requires patient, concerted, and negotiated solutions. Unfortunately, as observed by the Millennium Project (2020), the employment of systems that facilitate foresight and decision-making on a global scale is infrequent.

2.2 The Opportunities and New Challenges for Education During Digital Transformation Driven by Growing Technologies

2.2.1 Growing Technologies and Digital Transformation Shaping the Society and Workforce

Exponentially growing technologies, such as biotech, neurotech, nanotech, new energy and sustainability, ICT and mobile technology, 3D printing, sensor technology, artificial intelligence, robotics, drones, and nanotechnology, are accelerating the digital transformation of economies and society, and are radically altering the industrial processes. These technologies will be the key to the transformation of industry 4.0. The widespread adoption by the manufacturing industry and traditional production operations of information and communications technology (ICT) is increasingly blurring the boundaries between the physical and virtual worlds, and giving rise to what is known as cyber-physical production systems (CPPSs). CPPSs not only link machines with one another but also create a smart network encompassing machines, properties, ICT systems, smart products, and individuals across the entire value chain and the full product lifecycle. The integration of sensors and control elements enables machines to be linked to plants, fleets, networks, and human beings. The interface between industry 4.0 and other smart infrastructures, such as those for smart mobility, smart grids, smart logistics, and smart homes and buildings, is of paramount importance. The advent of industry 4.0 with its multitude of networks and interfaces within the internet of things, services, data, and people, will result in enormous digital transformation to the manufacturing sector in the future (Deloitte, 2014). The development of science and technology has provided mounting evidence that technological progress has created a "sagging middle" in the labor market, whereby machines and computers are replacing employees in many routine jobs in the middle of the income distribution, contributing to increases in the income inequality (Bakhshi & Windsor, 2015). World Economic Forum's "The Future of Job Report 2018" finds that as workforce transformations accelerate, the window of opportunity and new challenges for proactive management of this change is rapidly closing, necessitating that those businesses, governments, and worker must proactively plan and implement a new vision for the global labor market. While many technological innovations have resulted in increased productivity for workers, rather than complete job displacement (Glenn & the Millennium Project Team, 2019), technology can replace workers in routine tasks that can be easily automated and complement workers in tasks that require creativity, problem-solving, and cognitive skills. To thrive in the digital workplace, workers will require not only digital skills but also a diverse set of skills, including collaboration, communication, critical thinking, leadership, and creativity (OECD, 2020a, 2020b). As the workforce transformation unfolds, several challenges emerge for workers: (1) They need to adapt to changes in occupational categories in various ways; (2) Self-development becomes an important need for people; (3) The fundamental nature of work is being reshaped; (4) Humans should have a leg-up on automated technologies—soft skills. Education will need to react to the new situation and cultivate the future workers to adapt to the changes brought about by the revolution.

2.2.2 The Potentials of Promoting Education with Intelligent Technologies

The development of new technologies such as artificial intelligence can enhance people's ability to explore themselves (such as life and health), reshape the relationship between people and nature (such as the earth, energy and the universe, etc.), and catalyze the development of science and technology. Large-scale digitization and application of AI will bring new opportunities for education when researchers try to integrate it into school education. (Liu et al., 2018; UNESCO, 2019a, 2019b, 2019c).

- **Facilitating supply-side structural reforms in education**. Intelligent technologies can improve the quality of education through supporting educational practices in the undeveloped areas, creating national education platforms powered by cloud computing and big data, and supporting continuous quality improvement. Additionally, these technologies can increase the efficiency of educational resource distribution and productivity in the grand educational systems through infusing advanced technologies into education.
- **Transforming evidence-based policy planning processes by the use of data**. Integrating or developing AI technologies and tools can help upgrade education management information systems (EMIS), and enhance data collection and processing. With massive data collected, AI algorithms can make data-driven problem identification, decision-making and evaluation to assure a more equitable, inclusive, open, and personalized provision of education management.
- **Reshaping instructional environment and models**. AI platforms and learning analytics are revolutionizing learning environments that support the flexible instructional process. Intelligent Tutoring Systems (ITSs) and instructional robots can support personalized learning by accessing learning behavior data, providing immersive learning environments, and contributing to a transformative shift in learners' attitudes and emotions. Furthermore, these technologies can also enable the provision of flexible learning pathways and support the accumulation, recognition, certification, and transfer of individual learning outcomes.
- **Providing the most appropriate learning support service**. AI technologies can provide the most appropriate learning content, instructional experts, and learning resources to help learners through adaptive learning support systems. Based on the utilization of AI, new models for delivering education and training can be introduced to different learning institutions and settings, benefiting students, teaching staff, parents, and communities alike.
- **Improving the validity and accuracy of the assessment**. AI can enable the evaluation of the multiple dimensions of students' learning outcomes. The techniques of learning analytics can harness comprehensive learning data, ranging from elementary schools to higher education, to offer innovative assessment solutions. By using multiple types of analysis and modeling methods, AI can effectively interpret and predict learning performance. Therefore, the validity and accuracy of the assessment can be greatly improved through the application of AI.
- **Facilitating teachers' professional development and role change**. AI can promote the changes in teachers' roles by replacing parts of their routine work, such as lecturing, grading homework, and other duties. The concept of a dual-teacher model, consisting of a teacher and a virtual teaching assistant powered by AI, can allow for teachers' routine tasks to be complemented by AI assistants.

This, in turn, enables teachers to devote more time and attention to student guidance, personalized one-on-one communication, and helping students cope with complicated problems or difficulties.

- **Ensuring equitable and inclusive access to education**. AI-related technological breakthroughs provide an opportunity to improve access to education for marginalized people and communities, individuals with disabilities, refugees, out-of-school populations, and those living in remote areas. Furthermore, AI could promote high-quality education and learning opportunities that transcend the barriers related to gender, disability, socioeconomic status, ethnicity or cultural background, or geographic location.

2.2.3 *The Emerging Challenges for Education in an Intelligent Era*

Along with these opportunities, there are growing concerns about the challenges surrounding global education, as we approach the intelligent era where the integration of emerging technologies into teaching and learning becomes increasingly prominent (Liu et al., 2018; UNESCO, 2019a, 2019b, 2019c).

- **Improving the "quality" of education**. In our contemporary world, there is a shift in focus within education from "quantity" to "quality". However, the current education systems in diverse contexts are often deficient in equipping students with the requisite skills, knowledge, and competencies required to effectively cope with the social and economic challenges of our global age (Tarragó & Wilson, 2010). As what has been discussed in UNESCO report "The State of The Global Education Crisis: A Path to Recovery", as the crisis associated with the COVID-19 children in many countries had missed out on most of their learning and thus the quality of learning became a concern, and how to recover from this learning crisis is a challenge.
- **Innovating the methods of teaching and learning**. It is believed that despite technological advances and changing societal needs, most of the schools have maintained a consistent layout and curriculum for students and that there is little change between classrooms in the nineteenth century and the twenty-first century (Hughes, 2018). Hence, the education systems of many countries hinder the development of creativity, critical thinking, and technical skills in learners. In order to address this issue, educators need to forgo primitive ways of teaching and be proactive in identifying the primary obstacle to achieving the goal of worldwide educational access and quality. Schools have the duty to educate all children and therefore must develop innovative teaching approaches that cater to individual differences and benefit all learners (UNESCO, 2020). The pandemic highlighted the need to embrace new and viable perspectives on education. The educational careers of countless students—approximately 1.6 billion—were at

risk. As a result, this placed strong pressure on educational leaders and policy-makers to "think outside the box" and promote progressive and lifelong learning in the post-era of educational disruptions (Pokhrel & Chhetri, 2021; World Bank, 2021). Educators had to throw away the accustomed old-fashioned ways of delivering education and design new modalities of instruction and learning spaces that are more flexible, seamless, engaging, interactive, practical, and learner-centered. A form of education that transcends geographical distance, cultivates the innate talents of each learner and enhances their motivation to learn will build a strong human capital with transferable skills essential for solving real-life problems.

- **Qualified teacher shortages**. To ensure the quality of educational achievements, teachers are recognized as one critical factor. According to UNESCO (2023a, 2023b), there is a large gap in the quantity and quality of teachers. Such shortage poses a persistent and formidable challenge on a global scale. Despite a global challenge, it is particularly severe in certain regions, such as sub-Sharan Africa, where there is a dire need for qualified teachers. This challenge has been recognized as a critical impediment to progress in achieving the Sustainable Development Goals, specifically SDG4 (International Task Force on Teachers for Education 2030, 2022; UNESCO, 2023a, 2023b).
- **High dropout rates and learning losses**. School closures along with other factors, such as prolonged and repeated classes, have resulted in alarmingly high dropout rates, ranging from 1% to more than 35%. Based on the estimates from the UNESCO Global Education Monitoring Report, 244 million children and youth between the ages of 6 and 18 worldwide were still deprived of access to education in 2022. Notably, a higher dropout rate is also found among older students and has a disproportionate impact on the most vulnerable students. For example, female students are particularly susceptible to a higher risk of dropping out (Moscoviz & Evans, 2022; UNESCO, 2023a, 2023b).
- **Ensure inclusion and equity for AI in education**. The AI divide and disparities in AI development across countries, the risks of polarization between those who have access to AI and those who do not, should be paid close attention to during the utilization of AI. The least developed countries are at risk of suffering new technological, economic, and social divides as AI continues to evolve. Some main obstacles, such as basic technological infrastructure must be faced to establish the necessary conditions for implementing new strategies that take advantage of AI to improve learning.
- **The educational value of AI**. In order to realize the educational value of AI and establish a comprehensive understanding of its premises, conditions, and constraints within the context of schooling, it is imperative for educational practitioners to prioritize and address these key issues about the specific value of AI for education and how to maximize this value.
- **Prepare teachers for technology-powered education and prepare AI to understand education**. Teachers must acquire new digital skills that allow them to effectively and meaningfully use AI in their pedagogical practices. Similarly, AI developers must gain a deep understanding of the work and needs of teachers,

students, and educational administrators, and develop educational solutions that are sustainable and applicable in real-life educational environments.

- **Teaching and learning experience in a human–machine coexisting environment**. Human–computer collaboration allows learners to have different learning experiences. However, it is important to acknowledge that technology itself does not always function in a manner that effectively facilitates instructional goals to meet humans' expectations. In some instances, technology can even produce exactly the opposite effects, such as generating distractions and negatively affect learning outcomes.
- **Technology governance for harmonious human–machine development**. Considering the benefits and risks associated with AI applications, the real challenges lie in determining what aspects of AI should be governed and how they should be governed. AI represents more than just a technical breakthrough in a single field or industry; it encompasses a fundamental transformation, including data standardization, platforms for social service, homonymous development of intelligent systems across multiple domains. These aspects may require comprehensive governance measures to ensure effective, responsible, and ethical AI practices.
- **Develop quality and inclusive data systems**. If we are heading towards the datafication and digital transformation of education, the quality of data should be our chief concern. It´s essential to develop state capabilities to improve data collection and systematization. The advancements of AI present an opportunity to increase the importance of data and the capability of data processing in educational system management.
- **Develop a comprehensive view of public policy on AI for sustainable development**. The complexity of the technological conditions necessary for progress in this field of AI requires the alignment and coordination of multiple factors and institutions. Collaboration and cooperation between public policies at both international and national levels are essential for creating an ecosystem of AI that serves sustainable development.
- **Effective collaboration between different groups and technical governance**. The key to integrate AI into schooling is effective collaboration among governments, private sectors, and academia. The complimentary between industry and academia will support infusing AI into schooling through algorithm optimization, research on educational methods, and coordination of educational resources.

Ethics, Accountability, Transparency, and Security of Smart Technologies.

- The advent of AI in education gives rise to numerous ethical concerns, such as equitable access to the education system and resources, personalized recommendations for individual students, personal data concentration, liability for AI decisions, impact on work, data privacy, and ownership of data used to train algorithms. It is crucial to be cognizant of the dilemmas of balancing between open access to data and data privacy protection. People should also be mindful of the legal issues and ethical risks related to data ownership, data privacy, and data availability for the public good.

2.3 Conclusion

Taking the swiftly changing nature of human society and the emergence of multiple potential futures into consideration, there arises a necessity to rethink and reimagine the future of education (UNESCO, 2021). Inevitably, the future is characterized by rapid changes, complex challenges and problems that will demand the need to substitute conventional methods of teaching and learning for innovative models that will provide different learners with opportunities to co-evolve with the advancement in the world. Such innovative approaches can be Design-based Learning (DBL), which have the capability to refashion the old strains of teaching and learning through innovative design approach and pedagogy and thus reshape education. Innovative design brings new perspectives to re-design the whole educational system. Furthermore, Design-based Learning (DBL) is a learning strategy that requires students to use their theoretical knowledge to develop an artifact or system to tackle a real-life problem (Azizan & Abu Shamsi, 2022). Encouraging students to engage in more collaborative tasks such as project-based learning, research, and problem-solving endeavors their involvement in teamwork and promotes the acquisition of crucial competence (Delaney, 2019). Past studies have evidently revealed the potential benefits of DBL in developing learners' innovative competencies (Azizan & Abu Shamsi, 2022; Huang et al., 2020; Zhang et al., 2021). In this book, the concept of design and learning is proposed as a pathway to envision the unforeseeable futures of education in an era marked by heightened global interest in promoting a sustainable and harmonious society.

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Part II
Emerging Models of Design Thinking for Education

Chapter 3
Design and Design Thinking: Elements, Models, and Implications

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Abstract The significance of design thinking in developing innovations has increasingly attracted the interest of numerous individuals, groups, communities, and domains. This chapter takes a theoretical and hands-on approach to the concept of design thinking. The chapter organizes diverse academic works through a methodical study of the literature to better comprehend the context, history, process, and outputs of design thinking in various sectors of life. The review specifically addresses these issues.

What are the main attributes of design thinking that make it so effective in education?

What are the design-thinking-specific strategic components?

What are the most popular models of design thinking?

What are the various educational contexts where design thinking is used?

The purpose of this chapter is to summarize the current body of knowledge so that readers will have a better grasp of design thinking's function and importance in various sectors of life. The strategic tools, models, and implementation are discussed across diverse operations in this chapter.

3.1 Introduction

The concept of "design thinking" has origins in many different fields, and early writing on the topic typically, though not always, associates it with engineering, architecture, and similar design professions (Renard, 2014). Design Thinking is a problem-solving strategy that puts the needs of people first. It produces creative, workable solutions by offering chances for experimentation and redesigning. According to Tim Brown, "Design thinking can be described as a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity" (Brown, 2008). Design thinking is both a method and a tactic. With teams

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of specialists, it aids in the development of innovative outcomes and services. As a tactic, it breaks down the entrenched attitude that daily job tasks engender in an individual's thinking (Efeoglu et al., 2013).

It is a non-linear, continuous approach, to comprehend users, question presumptions, reframe challenges, and develop original solutions for prototyping and testing (Dam & Siang, 2020a, 2020b). The design thinking method's deliberate nonlinearity is one of its demonstrative traits. Designers frequently revise their approaches to problem-solving and exploration. They swiftly produce potential answers, create straightforward prototypes, and improve on these initial proposals while taking into account substantial feedback from the customers or clients in order to arrive at an ultimate answer (Luchs, 2015).

Design thinking is most effective when used in circumstances where the problem is ill-defined or if a game-changing notion or proposal is required (Dijksterhuis & Silvius, 2017). Such difficulties have been referred to as "wicked problems" in literature. Wicked problems are issues that appear to be intractable to address because of numerous interrelated aspects. Rittel and Weber (1974), described wicked problems based on ten-pointers. The following list summarizes the ten distinguishing characteristics.

- "There is no definite formulation of a wicked problem."
- "Wicked problems have no stopping rules."
- "Solutions to wicked problems are not true-or-false, but better or worse"
- "There is no immediate and no ultimate test of a solution to a wicked problem."
- "Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial-and-error, every attempt counts significantly."
- "Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan."
- "Every wicked problem is essentially unique."
- "Every wicked problem can be considered to be a symptom of another [wicked] problem."
- "The causes of a wicked problem can be explained in numerous ways. The choice of explanation determines the nature of the problem's resolution."
- "[With wicked problems,] the planner has no right to be wrong."

Diverse viewpoints, collaborative effort, refinement, encouraging a diagrammatic depiction, emphasizing linkages among independent variables, and focusing on opportunities are the major strategies for addressing wicked problems through design thinking (Ritchey, 2013). Despite design thinking's popularity, there isn't a platform where the fundamental concepts of the idea are made clear. The existing body of literature on design thinking is fragmented, disjointed, or narrowly focused without offering a comprehensive perspective. Beginners may find it difficult to put the design thinking approach into practice because of this. Thus, this chapter aims to close this gap by addressing the following research questions through an extensive literature survey.

(1) What are the main attributes of design thinking that make it so effective in education?
(2) What are the design-thinking-specific strategic components?
(3) What are the most popular models of design thinking?

The current chapter offers a thorough framework that unifies prominent design and design thinking components and models. Particular attention is paid to the role of design thinking in education at key points. This can provide a well-structured basis for understanding and effectively using these principles for both scholars and practitioners. The study's findings may offer fresh avenues for future investigation, filling in knowledge gaps and motivating scholars to investigate developing facets of design and design thinking.

Following is the chapter's organization:

- The conceptual overview provides clarification of the origin and evolution of design thinking. It also summarizes previous published researches of significant importance.
- The case applications focus on the successful application of design thinking in various prominent sectors.
- The methodology section outlines how samples were chosen in order to address the research questions.
- The discussion and insights section provides a detailed explanation of the outcomes of this chapter.
- The conclusion section provides a comprehensive and concise summary of the entire study focusing on the key findings of this chapter.

3.2 Conceptual Overview

The practice of design thinking is one that is inherent in the design mechanism. Design thinking, however, did not become a notion until the second half of the twentieth century. To build a solid foundation for the following sections of this chapter, this segment mainly centers on the genesis and evolution of design thinking and then explores some of the well-known significant works in this field.

3.2.1 Origin and Evolution

The 1950s and 1960s saw the first indications of design thinking, however these allusions were more related to engineering and architecture at that time (Kimbell, 2011). Beginning with the 1960s, a line of inquiry concentrated on the choices and techniques of designers. This was popularized as the "design methods movement"

(Buchanan, 1992; Jones, 1992). These experts aimed to comprehend the procedures and strategies employed by designers, particularly in situations when design challenges were escalated (Jones, 1992).

The initial conceptualization of design was focused on the concrete product dimension. The engineering and architectural roots of design can be attributed to this conceptualization. Let's use an example to further explain this. There is a basic cloth. The specialists use design to turn this simple fabric into a fancy garment. Similarly, there is an old car. This ancient car can be given a design makeover so that the product as a whole has some sort of qualitative enhancement. If so, then the design process will center on the materiality or concrete form. This design philosophy was strongly supported by Christopher Alexander in 1971. The final product and its physical form were of utmost importance in this notion of design. An exact opposite idea of design was put forth by Herbert Simon. Simon (1969) made the argument that designers' tasks are not always representational. The emphasis is on abstract delineation to produce a desired scenario or circumstance (Simon, 1969). According to Simon, a logical collection of measures used to address a specified challenge is called design.

All of these studies concentrated on the idea of design, but none of them addressed design thinking. One of the first analyses of the idea may be found in Peter Rowe's Design Thinking, which was first released in 1987 (Rodgers & Winton, 2010). Rowe aims to describe design as a form of thinking that involves both reasoned deliberations that are driven by guidelines and imperatives as well as the creative development and application of design concepts. In his study, the operational features of design thinking were also described for the first time. In a groundbreaking research "Designerly Ways of Knowing," Nigel Cross addressed the underlying principles of the manner in which designers approach problem-solving. He made a comparison between how designers approach challenges and the non-design-related approaches people come up with for problems encountered in everyday life (Cross, 1982).

The widespread adoption of design thinking began in 1991. This is mostly due to Kelley's IDEO. IDEO organized the lexicon of design thinking into a viable framework. Over the years, they created their own customer-friendly thesaurus, procedures, and resources, which improved accessibility for persons without formal training in design techniques (Ilipinar et al., 2011). Buchanan's research titled "Wicked Problems in Design Thinking" developed the concept of design into a more all-encompassing form of "design thinking" that could potentially be used to solve almost any problem, whether it be with a physical object or an abstract system (Buchanan, 1992). Margolin (1995) suggested that design experts should devote greater consideration to the connections between design and engagement with society.

Despite the fact that a large portion of the recent discussions of design thinking are connected to one design firm, IDEO, design thinking first became popular in the 1950s and 1960s. The approach began by fusing the tactical, technological, and social demands of the period, and it evolved gradually across the years to grow into the preeminent breakthrough paradigm that remains in the present time. Design thinking is still being investigated and improved by people at the core of the discipline and is gaining momentum spanning numerous sectors.

3.2.2 Recent Researches in Design Thinking

The content of this section builds on a number of recently published works, specifically from the last 5 years, on design thinking that are geared toward the education sector.

Li et al. (2019) extended previous research on design and design thinking and explained how designing tasks could assist students in discovering and developing their design thinking across a range of subject areas.

Hennessey and Mueller (2020) evaluated curriculum materials produced using a design thinking framework in collaboration with an acquaintance in the tech-ed industry and a team of experienced teachers. The results showed that teachers reflected favorably on the design thinking approach. Results indicate that design thinking-based learning is consistent with the transition away from project-based instruction and toward experience learning targeted at developing global capabilities.

Lin et al. (2020) investigated how design thinking benefited in achieving the various levels of curriculum objectives. The results showed that design thinking can be used to advance both low-level and high-level educational objectives.

Lynch et al. (2021) carried out an exploratory case study of students' reflections during, and after participating in a course that employs design thinking to teach entrepreneurial skills through a case study utilizing sophisticated technology. The findings demonstrated that participants had begun to use design thinking outside the bounds of the course, which is evidence of transformative learning.

The effects of a design thinking integrated PBL strategy on college students' learning motivation and creativity were examined by (Kuo et al., 2022). The experimental group was trained using design thinking techniques, and the results showed that their motivational scale and creativity graph were enhanced. This information was gathered by quantitative survey/tests and qualitative interviews.

Li and Zhan (2022) reviewed 44 highly qualified empirical studies to explore the future research prospects for design thinking integrated learning (DTIL) in K–12 education. The results show that design thinking has a huge potential for teaching in K–12 education.

McLaughlin et al. (2022) used a mixed methods approach to investigate how educators and pupils perceive design thinking in higher education courses by combining surveys of faculty and students with semi-structured interviews. The results show that design thinking is hailed as an essential process of thought combining creation, group comprehension, using evidence to support arguments, testing, and assessment.

Razali et al. (2022) conducted a systematic review of 25 articles to answer two questions: (a) "What are the approaches to design thinking in education?" (b) "What are the challenges of design thinking in education?" In response to the first query, the methods are collectively referred to as "pedagogical approaches." A scarcity of resources, expertise, time, and training are just a few of the difficulties teachers encounter. Students struggle with collaborative work, originality, lack of strong ideas, and disarray and discontent when using design thinking. In order to overcome these difficulties, educators must constantly be receptive to fresh and latest information.

Shé et al. (2022) designed and delivered an online course using design thinking. The results of this study suggest that instructional designers can employ the design thinking process to develop compassion with their students, ensuring that they effectively participate and complete the objectives of the course.

3.2.3 Case Study

The following case studies highlight some of design thinking's successful implementation in various industries (Table 3.1).

3.3 Methodology

3.3.1 Search Strategy

The data set for this chapter is based on an organized search approach that consisted of searching through the databases of IEEE, Elsevier, Springer, RAID, ESCORICS, Google Scholar, SCOPUS, Web of Sciences, and other pertinent channels for pertinent articles in the English language made public within the time span of 2015 up to 2023 using key phrases and blends of multiple search terms like design, design thinking, prototyping, strategies, history, case studies, human-centered design, emphasize, ideate, persona, journey mapping, etc. to name a few (Fig. 3.1).

3.3.2 Study Inclusion Strategy

A large number of over 31,000 papers between 2015 and 2023 were returned by the initial search. The phrase "design thinking" was made a necessary key phrase in the publication's title in order to organize the study. The total amount was reduced to 8,950 items as a result. Similarly, only open-source papers or publications whose complete text was accessible were included. This decreased the total to below 700. In total, 487 papers were taken into consideration as they centered on those investigations that contributed to answering the research questions of the present study.

Table 3.1 Prominent Real-Life Examples of Design Thinking Successful Execution

Domain	Prominent case example	Citation/References source
Food and beverage industry	A decline in sales and low-profit margins were plaguing the food and beverage sector. Starbucks implemented design thinking by developing the "My Starbucks Idea" platform in 2008. The execution of the customer-generated ideas gave the clients the impression that they were being heard. Starbucks continues to use design thinking, which has radically increased its appeal	Leavy (2012)
Healthcare	Oral-B aimed to make the traditional children's toothbrush simpler and less stressful for kids to use. To do this, Oral-B began collaborating with the design firm IDEO, which places an enormous value on the design thinking methodology. Through observation, they discovered that children were striking their own faces with their toothbrushes when brushing their teeth as they were clenching their fists and holding them higher than normal. This awareness led to the discovery that youngsters need plump, soft toothbrushes. As a result of this discovery, Oral B held the world record for the top-selling children's toothbrush for a period of eighteen months	Lou (2022)
Footwear	It was challenging for Nike to establish itself as a major player in the skating industry. The team was able to gain a deeper understanding of the wants and needs of the skate community thanks to the design thinking methodology. After incorporating insights from customer involvement and the expertise of skateboard experts on their design team, Nike unveiled the Nike Dunk SB. Nike has had a ton of success in the skateboarding community since introducing its Nike SB shoe line	Kim and Ryu (2014)
Entertainment	Design thinking served as inspiration for Netflix's 2011 "User Experience (Web interface)" overhaul. Netflix started creating its own exclusive streaming shows and films. In 2016, Netflix revised its primary landing page to grab the interest of consumers, tailoring it once more to the demands of the marketplace. They introduced auto-play teasers that premiered on mouse hover rather than static pictures or series banners. As a result of recognizing and meeting consumer requests, Netflix has been dominating the market ever since	Steinke et al. (2017)

(continued)

Table 3.1 (continued)

Domain	Prominent case example	Citation/References source
Cosmetics	The introduction of sachets in India by CK Ranganathan sparked a revolution when companies like Sunsilk, Clinic Plus, and foreign brands dominated the shampoo industry. He conducted a market study on residents of small towns and discovered that they spend Rs 2 a month on sachets. If someone washes their hair four times per month on a typical basis, they would only need to spend half a rupee per week. In 1983, CK Ranganathan sold Chik shampoo sachets for 50 paise. The voyage of CavinKare officially began at this point. In only that one year, this brand sold around 1 million sachets. What began with a capital of Rs 15,000 grew into an empire worth 1.1 billion in 2012	Saeed et al. (2012)
Education	The Stanford D-school uses techniques from design thinking to develop educational experiences that enable people to realize their capacity for innovation and use it to positively impact society as a whole. To create initiatives that solve real-world issues, academics, practitioners, and students from various fields, viewpoints, and backgrounds collaborate with businesses, governments, and non-profit organizations	https://dschool.stanford.edu/about
Technology	In order to determine the reason why older people were not buying smartphones, Samsung undertook a study. The survey found that users were turned off by the manual's typical guidelines and coded vocabulary. Samsung provided a large-font tutorial in the format of a book using design thinking ideas. There was only a single instruction per page. The book's interactivity was by far its greatest asset. It made it possible to literally tuck a phone inside a book. Following that, the user could configure a device without leaving the text. Through the application of design thinking, Samsung emerged as a sales and customer connectivity powerhouse	Yoo and Kim (2015)
Transportation	Uber's popularity is primarily attributable to the usage of design thinking to enhance client satisfaction. By empathizing with the customers, the Uber unit was able to determine that the waiting period is the primary factor affecting the client's overall perception. Putting this realization into use, Uber became the most well-known form of transportation in the entire world with the aid of this customer-centric strategy	Liedtka and Kaplan (2019)

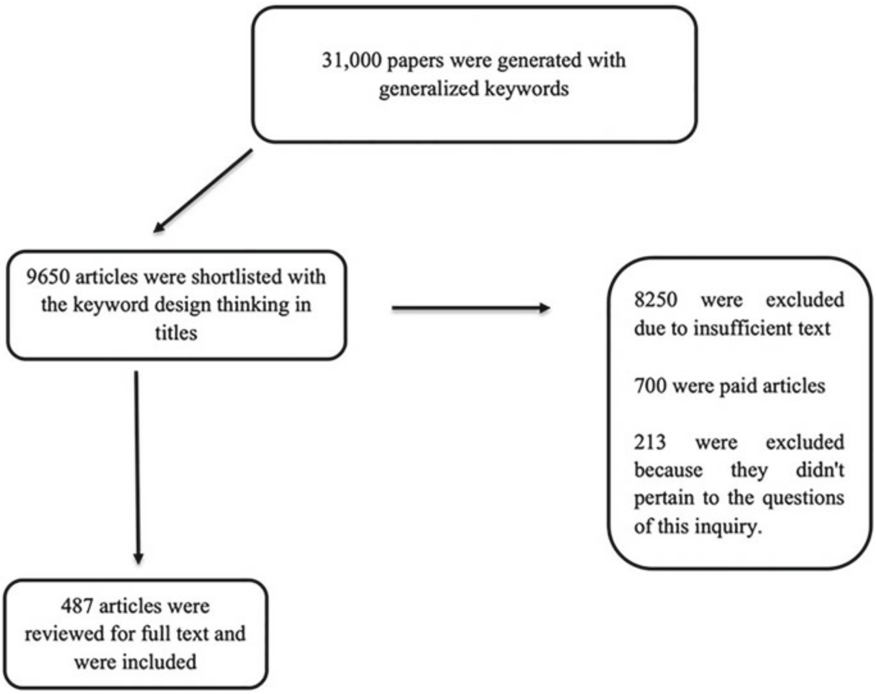

Fig. 3.1 Search Algorithm (*Source* Authors)

3.3.3 Study Exclusion Strategy

All studies published prior to 2015 were instantly excluded because the current study solely focused on an established time frame. By standard procedure, abstracts, documents, reports, and any other brief or partial information piece were removed since they lacked the necessary documentation of the full study process. The paid publications were also omitted. Further investigations that didn't address the study concerns of the current research were eliminated as well.

3.3.4 Data Collection Strategy

Using generic keywords like, "design thinking, education, human-centered design, design process, design integration in classroom, design thinking pedagogy, design ideation, design driven innovation, user-centric design, prototyping methods, design education, iterative design, design research, design driven innovation etc." the current investigation generated 31,000 research papers in total. A total of 9650 publications were found after screening the studies by their titles that referenced design thinking, of which 8250 were eliminated because they contained insufficient text or had to be purchased and 213 were excluded because they didn't pertain to the questions of this inquiry. Following the filtering procedure, 487 studies in total qualified for inclusion in the study.

3.4 Discussion and Insights

This section gives a summary of the key learnings from the literature review for the four research questions this investigation focuses on:

(1) What are the main attributes of design thinking that make it so effective in education?
(2) What are the design-thinking-specific strategic components?
(3) What are the most popular models of design thinking?
(4) What are the various educational contexts where design thinking is used?

3.4.1 RQ1: What Are the Main Attributes of Design Thinking that Make It so Effective in Education?

There isn't a single attribute that provides a distinct benefit to design thinking. In reality, the combination of all the characteristics is what attracts people to design thinking in practically every industry, including education.

Human-centeredness. Design Thinking is described as a multifaceted, continuous, human-centered strategy that promotes improvement and invention (Carlgren et al., 2016). Design thinkers regularly engage consumers in the iterative collaboration and validation of hypotheses and prototypes to guarantee that the results of their innovation endeavor bring meaning to the people who use them and are relevant and accessible (Norman, 2017). The complexity of the issues tackled in design thinking initiatives contributes to the significance of a human-centered strategy. To comprehend the intricacy of problems, render meaning out of them, and make them achievable, these kinds of challenges should be approached from the viewpoint of human beings (Liedtka, 2015). By using design thinking in education, problems are solved with the requirements and standpoints of the students in mind. This aids educators in customizing their instruction to fit the learning styles, aptitudes, and inclinations of their pupils (Van De Grift & Kroeze, 2016).

Here, for the sake of clarification, let's look at an example. The biology teacher in a high school class observes that some students are having trouble comprehending the mechanisms behind cells. Instead of just lecturing, the instructor uses design thinking to produce engaging simulations and visual aids that accommodate various learning preferences. Students' involvement and understanding are improved by this method.

Empathy. According to Gasparini (2015), empathy is a natural, emotional, and bonded experience that allows one to feel what others are going through. You consider what someone else is experiencing as you delve into their psyche. Empathy is the primary driving force behind the application of the human-centeredness principle. One of the classic cases shared by IDEO firm with the aid of empathy, design thinkers can learn specifics about the needs of the clients. Design thinkers acquire the skills of observation, paying attention, and developing empathetic perspectives that result in human-centered approaches to problem-solving through inquiry into the context (Carroll, 2015). Since authentic educational experiences need instructors to engage with students on a more profound level, this quality is particularly important in education (Bush et al., 2022).

As an example, let's consider this situation during final examination week, a university professor who uses design thinking chooses to tackle the concern of student anxiety. To assist students, unwind and do better in examinations, the professor works with the counseling division to establish stress-relief stations across the campus. These stations provide things like positive psychology therapy and mindfulness sessions.

Experimentation. Design thinking places a strong emphasis on experimentation (Micheli et al., 2019). Design thinking adopts an iterative methodology. It is distinguished by a process of experimentation that evaluates a variety of possible alternatives with project collaborators and ultimate customers (Beverland et al., 2015). Sketches, mockups, and prototypes are useful tools for making ideas tangible through refinement and exploration. Prototyping is seen as a tool for testing and refining ideas. To provide a genuine experience of what the idea might be in practice and gain trustworthy feedback, the prototypes are tested with target consumers (Pisano, 2019). Based on the input received, the experimentation is continued to provide a high-quality result. The cycle of ideation, prototyping, testing, and refining is a key component of design thinking. Students are encouraged to try new things, take lessons from mistakes, and keep refining their concepts and answers thanks to this continuous experimental methodology (Rao et al., 2022).

As an illustration, students in a secondary school history course are required to come up with creative ways to instruct their classmates about an era in history. Students develop and evaluate multiple teaching strategies through iterative cycles, including role-playing, making videos, and interactive presentations. Through this process, they not only gain a deeper comprehension of the subject but they additionally improve their ability to communicate and solve problems.

Collaboration Across Disciplines. Design thinking is frequently seen as a technique for resolving wicked or poorly defined real-world issues. By bringing together individuals from different sectors and groups, creative and need-based practical solutions can be developed (Beverland et al., 2016). Creating interdisciplinary teams can aid in addressing the complexity of the task and ensuring that the scientific, operational, and human facets of the challenge are all represented (Glen et al., 2015). As a result, it is believed that a key component of design thinking is the collaboration of many perspectives (Carlgren et al., 2016). Students collaborate in multidisciplinary groups to make the most of different viewpoints and expertise while developing a feeling of cooperative advancement and shared accountability (Inglesis Barcellos & Botura, 2018).

As an example, let's consider, the high school students are required to create a sustainable community for their science projects. Students with expertise in science, math, artwork, and humanities work cooperatively to build an all-encompassing strategy that takes social, economic, and environmental elements into account, fostering a holistic knowledge of complicated challenges.

3.4.2 RQ2: What Are the Design-Thinking-Specific Strategic Components?

The majority of researchers highlight the applicability and value of a number of design thinking-related tools and techniques. Here is a list of the most popular strategic design thinking elements, along with an explanation of each.

Ethnography. This term refers to a range of qualitative research techniques that are centered on getting to know consumers on an in-depth basis by seeing and interacting with them in their natural environment. Observations, interviewing, discussions, taking notes, recordings, etc. are used in ethnography. In the investigative initial stage of design thinking especially where empathy is prioritized, ethnography is a key component. Before proceeding on to the building of solutions, design thinking starts with complete involvement in the customer's experience to gain a thorough grasp of their requirements as well as present circumstances (Glen et al., 2015).

Visualization. It is the use of either narrative or visual representations. Apart from conventional graphical representations, it can also take the shape of metaphorical storytelling, the use of sticky notes, or scribbling down specific thoughts on bulletin boards so they can be explored and improved upon (Newman, 2017).

Persona. A persona is a fictional figure that symbolizes a broader group of people that have similar traits, goals, and expectations. Personas serve as a substitute for actual consumers when an issue is analyzed and a fix is being designed. The use of personas enables communication among all members of the research and design teams (Fehér & Varga, 2019). The process of developing personas is cyclical and involves combining and examining customer information from multiple consumer study techniques. Once a persona is created, a designer utilizes it to comprehend and relate to the consumer. The resulting consumer insights aid designers in their design choices as they generate ideas (Dahiya & Kumar, 2018).

Customer Journey Mapping. It is the practice of capturing and keeping track of every interaction a client has with a service, not only what occurs to them but also their reactions. These strategies aim to improve customer interactions by raising the standard of each touchpoint corresponding to the overall experience. Customer journey maps often show connections horizontally in accordance with the sequence of the process. After that, the timeframe is divided into the before, during, and after phases. (Rosenbaum et al., 2017). The generated maps are strong, graphic tools that illustrate customer reactions and encounters with all the consumer actions. Sticky note mapping is a fairly easy method for customer journey mapping.

Prototyping. A prototype is an easy-to-use experimental representation of a suggested solution that serves to rapidly and inexpensively examine or verify ideas, design suppositions, and other parts of its conceptualization in order to ensure the experts employed are able to implement the necessary adjustments or possible shifts in strategy (Dam & Siang, 2020a, 2020b). Design Thinking includes prototyping as a key component. Prototyping makes it possible to test proposals effectively and make improvements to them swiftly.

3.4.3 RQ3: What Are the Most Popular Models of Design Thinking?

There are three models that are highly popular in the design thinking domain.

Double Diamond Process Model. This design was proposed in 2005 by the British Design Council. It has four basic phases: discover, define, develop, and deliver (Kwon et al., 2021). It highlights the iterative approach to finding the most effective answer, where the initial diamond centers around establishing the issue and the second diamond on solution development. "Discover" is the initial stage that aids in understanding what the issue is. The information acquired helps to "define" the problem differently. After the primary issue has been located, the "develop" stage accelerates the process by allowing for a wider exploration of ideas and designs. The team's chosen solution is improved in the last phase, "deliver." (Serio et al., 2023).

Hasso-Plattner Institute Model. The five-stage design approach "Empathize, Define (the problem), Ideate, Prototype, and Test" was proposed by the Hasso-Plattner Institute of Design at Stanford. Empathize aims to comprehend the experience of the consumer to the fullest extent possible before designing a solution for them (Lee & Park, 2022). Define generates the research data in order to provide the consumer's viewpoint for their design. Ideate creates a big pool of ideas that everyone on the team may use to look into an extensive spectrum of potential solutions. Ideas are given physical embodiment in the prototype phase. This experimental step seeks to pinpoint the ideal response to every issue discovered in the previous three stages. The top solutions that have been improved through prototyping are put to the test on actual end customers in the last stage (Waidelich et al., 2018).

IDEO's HCD Model. It was created by IDEO as part of a human-centered design approach, and it stands for Hearing, Creating, and Delivering (HCD). The customer is guided through a collaborative design strategy in this approach that is aided by exercises like expanding the art of listening, holding workshops, and putting ideas into practice (Grönman & Lindfors, 2021). This model constitutes of the following stages: Empathize, Define, Ideate, Prototype, Test, Implement and Evaluate (Grönman & Lindfors, 2021). Let's look at a hypothetical illustration of how these stages might be understood in an educational setting.

Problem: How to optimize the overall learning experience of students learning on an online platform?

Empathize: This stage will focus on acknowledging the expectations and issues faced by teachers and students when it comes to online learning. To get clarity on the effective and non-effective attributes, insights are gained from the teachers and students through interviews, questionnaires, and other modes of data collection. This stage's objective is to narrow down the most difficult problems, like feeling alienated, feeling uncomfortable with technology, and a lack of interaction.

Define: The information gathered will be utilized to identify the key issues and potential solutions. A problem statement will be generated after the analysis. An example of the problem statement in this scenario can be, "In what ways can we improve the effectiveness and engagement of online instruction for students across a range of age groups?".

Ideate: Brainstorming of multiple potential solutions to the discovered challenges will be done here. While thinking of solutions a special emphasis will be laid on promoting originality and adaptability. Some of the possible solutions for the problem identified in this hypothetical example can be interactive learning environments, virtual study groups, gamified learning scenarios, individualized learning paths, and more.

Prototype: Identification of a handful of ideas that have potential from the brainstorming stage will be done here. These ideas will then be transformed into prototypes. Preliminary versions of the prototypes that were chosen will be generated. An example of this can be creating mockups of new communication tools, interactive modules, online learning platforms etc.

Test: A limited sample of students, teachers, and parents participate in the testing of the prototypes. Their feedback on the usability, engagement, and efficacy of the suggested remedies is taken into consideration. Prototypes are iterated upon in response to user feedback.

Implement: The prototypes undergo refinement toward improved variants after considering findings from the testing process. The technology, content, and resources required to fully deploy the selected solution are being developed.

Evaluate: Emphasis is placed on tracking the solution's implementation and gaining information on its effects. The effectiveness of the solution in resolving the original issues and enhancing the online learning environment is evaluated. With the help of continual input and information analysis, the process is further enhanced.

The needs of numerous stakeholders were understood in this case using IDEO's HCD paradigm, which was then utilized to develop inventive solutions and refine them in response to user input. This strategy results in a virtual educational environment that meets users' demands and offers a more productive learning setting.

3.4.4 RQ4: What Are the Various Educational Contexts Where Design Thinking is Used?

Design thinking is not restricted to any sector but can be implemented in any framework, including education. It emphasizes comprehending user demands, coming up with original solutions, and iteratively improving those answers. The term "design thinking" is used broadly in education to refer to the different types of thought processes that take place while using the design method to address difficulties or obstacles in the actual world.

Curriculum. A rising number of academics and researchers in education have highlighted the intriguing possibilities of design thinking in enhancing curriculum and pedagogy (Anderson et al., 2017; Callahan, 2019; Revano & Garcia, 2020).

Education Policy. Design thinking is employed in educational policy planning to envision desired operations, outline the support that ought to be provided to teachers, and justify learning objectives (Hubbard & Datnow, 2020), (Kijima et al., 2021).

Lesson Plans. Learning by doing is given serious consideration in the interactive and innovative lesson plans that are made through design thinking. The needs of a learner in the twenty-first century are met by this (Albay & Eisma, 2021),

Alternative Schooling Paradigms. The challenges of the education sector are intimately related to the complexity that is rising because of the quickening evolution of knowledge. Education strategies that still place a heavy emphasis on teaching and reabsorbing information are frequently criticized. In order to support alternative methods of education and general growth, design thinking is crucial (Micheli et al., 2019; Parker et al., 2021).

21st Century Competencies. Education needs to equip students with the twenty-first-century skills. This process can be aided by design-driven learning opportunities (Koh et al., 2015; Luka, 2019).

Metacognition. Students are given opportunities to demonstrate the metacognitive abilities necessary for fostering lifelong learning, including chances to engage in self-evaluation, contemplation, and the enhancement of one's learning/problem-solving processes by the implementation of design thinking in education. Additionally, it enables students to demonstrate the self-control needed to prepare for and respond to real-life challenges (Kavousi et al., 2020; Soleas, 2015).

Cross-Disciplinary Programs. Interdisciplinary initiatives that combine several disciplines are offered by numerous universities. Students from different walks of life can effectively collaborate by using design thinking as a cohesive technique for problem-solving (Inglesis Barcellos & Botura, 2018).

Assessment Strategies. Design thinking is used to create more interactive and authentic assessment techniques that let students show their comprehension via projects and real-world applications (Wrigley & Straker, 2015).

Educational Technology Development. Design thinking is employed in researching and establishing new educational technologies and tools to ensure they truly satisfy the requirements of students as well as educators. This user-centered design methodology aids in the creation of intuitive and productive learning environments, applications, or software (Novak & Mulvey, 2020).

Redesigning Learning Spaces. Developing dynamic and adaptable instructional settings is a growing priority for educational institutions and organizations. Students, instructors, and other stakeholders could be included in the procedure of developing and reinventing both physical and virtual learning spaces by using design thinking (Casanova et al., 2020).

3.5 Conclusion

It is undeniable that conventional disciplines like engineering and architecture, serve as the foundation of design and design thinking. Many academics and researchers believe that design thinking is especially effective at solving complex or wicked problems. Designers must therefore start by establishing or defining the problem in order to proceed. The spectrum of potential solutions is also determined by how the issue in question is phrased or articulated. The capacity to combine information from multiple sources is a key component of the design thinking innovative problem-solving paradigm. Design thinking has an inter and multidisciplinary nature. Drawings or sticky notes are widely used in the course of problem-solving, along with the creation and use of frameworks, modeling, and prototypes. They serve as external visualizations of thought. Additionally, they offer different avenues for experiential inquiry and frequently serve as the foundation for the development of implicit expertise.

Design thinking in educational settings is a cutting-edge, student-focused strategy for tackling challenging issues and inspiring original thinking. It incorporates design-related principles into the classroom to promote teamwork, empathy, and iterative problem-solving. Some of the key implications of design thinking for the stakeholders in education is listed as follows:

3.5.1 Educators

Empowerment. Design thinking enables teachers to forego conventional approaches and utilize a more adaptable and versatile teaching style. It motivates them to test, improve, and personalize their instructional techniques in response to the demands of the students.

Collaboration. Design thinking helps to co-create educational opportunities in which instructors work together with pupils and among themselves. This encourages the exchange of knowledge, skills, and innovative ideas among instructors and fosters a sense of belonging.

Student-Centered Approach. The first step in design thinking is to comprehend the requirements, preferences, and difficulties that students face. With the students at the heart of the educational process, teachers can adapt their techniques for instruction to each student's requirements, motivations, and learning preferences.

Designing Curriculum. Instructors can utilize design thinking to create curricula that's more interesting and applicable to students' everyday lives. To create instructive learning experiences, design thinking considers the interests, skills, and learning preferences of the students.

Revolution in Teaching Approaches. Design thinking inspires teachers to try out novel methods of instruction, involving technology and interactive elements to strengthen student engagement.

Professional Development. Implementation of design thinking in educational settings promotes educators' advancement as professionals. Teachers can acquire new methods, resources, and tactics that will help them reinforce and involve their students with greater success.

3.5.2 Students

Empathy and Engagement. Design thinking centers the learning experience on the students. It promotes empathy among students by encouraging individuals to comprehend the wants and viewpoints of others. Their desire to study is increased by their involvement.

Critical Thinking. Students are pushed to think critically and find solutions to challenges in the actual world. They learn how to acquire data, assess circumstances, come up with ideas, and execute prototypes for creating workable solutions.

Creativity. Design thinking develops creativity and uniqueness in students' approaches to acquiring knowledge and solving problems by promoting experimentation and innovative thinking.

Problem-Solving Techniques

Design thinking guides students on how to solve issues in a methodical and original manner. Students can boost their analytical skills, consider issues from several perspectives, and come up with effective practical solutions by presenting educational challenges as problems to be addressed.

Ownership of Learning. Students take charge of their educational experiences by establishing objectives, pursuing interests, and monitoring their progress. Their sense of responsibility and capacity for self-directed learning are increased by this autonomy.

Real-World Relevance. Applying design thinking to real-life scenarios makes learning more pertinent and useful beyond the walls of the classroom.

Multidisciplinary Learning. Design thinking promotes the fusion of different academic fields to address challenging issues. This strategy enables learners see the immediate application of their learning across disciplines by reflecting the interconnectedness of the wider world.

Agility and Future Vision. In an age that is evolving quickly, abilities like versatility, figuring out solutions, empathy, and creativity are extremely essential. They give students the abilities they need to successfully negotiate ambiguity in a variety of different kinds of circumstances.

3.5.3 Other Stakeholders

Innovation. The design thinking methodology assists educational institutions to innovate and respond to transforming student specifications. Administrators can design settings that encourage experimenting and taking risks.

Parental Involvement. Activities that integrate parents in the design process encourage a sense of collaboration among parents and educators and increase parental involvement in their children's education.

Community Involvement. Schools that use design thinking can incorporate neighborhood companies, groups, and residents in projects, improving the link between the classroom and the outside world.

The integration of design thinking in education necessitates an evolution beyond conventional teaching strategies and toward one that is more adaptable, flexible, and pupil-centered. It promotes an outlook of constant development and openness for transformation. Design thinking can contribute to the creation of an increasingly vibrant and productive learning environment for all engaged stakeholders by placing an emphasis on empathy, cooperation, and innovative problem-solving.

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Chapter 4
Design Thinking Models and Tools to Support the Design Process

Cheng Fei

Abstract Design Thinking (DT) is not only about solving problems but it also delivers multi-dimension, innovative, and pragmatic perspectives which reflect users' demands. In education, DT has been regarded as a constructivist teaching methodology that integrates both divergent thinking and aggregated thinking. DT is a process from conceiving, prototyping to evaluation and finally defining innovative solutions. Such a process should be flexible, nonlinear, and dynamic. However, it depends on the application process of the Design Thinking models. Based on literature review and case study analysis, this section (1) reviews a list of typical Design Thinking models and their processes, (2) compares and analyzes these models to describe their core attributes and thinking characteristics, and (3) introduces commonly used thinking tools to explain how they provide new solutions for teaching design and engaging students in learning. This study provides new insights for educators to explore how to build a future school.

4.1 Introduction

Design Thinking (hereinafter referred to as DT) is never the exclusive domain of professional designers, whether they are artists, scientists, or educators, and every industry innovator iterates this process in unconscious practice. Repeatedly used by people as a means of breaking down the "black box" of design innovation, the DT model has become the mainstream process in design. A model is the underlying belief structure held by a person about how something works, which aids us in translating complex phenomena into usable and understandable paths. It assists us in understanding the truth of how things work and what we should do when mistakes occur in order to solve problems (Norman, 2010). One of the most important aspects of designers' work is to provide people with an appropriate conceptual model, similar to creating a "file structure" in a computer, so that people can see the operation process, practical methods, practical tools, and solutions that can be taken into account when

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problems arise, and to provide understanding and reference for others. The model is used to simplify the world, and for complex phenomena, it is really important to understand and apply the model thinking. In the 1970s, Noel Burch proposed four levels of perception: (1) unconscious unconsciousness (not realizing you don't know), (2) conscious unconsciousness (realizing you don't know), (3) conscious consciousness (realizing you know), and (4) unconscious consciousness (not realizing you know). In today's society, the skills that are still required for life, work, and study are essentially mental operations. We can help students cultivate these skills through learning, practice, development, and application, and eventually develop the fourth level of unconscious thinking habits, and the cultivation of such skills is dependent on the cultivation of model thinking. In academia, we use models to explain and verify data, allowing scientific progress to continue. In real-life, we use models to speculate, design, and act on new ideas and possibilities, as well as to exchange ideas and improve understanding in teamwork. Models are useful because they can clearly list the conditions required for specific results. For example, we can use models to examine the conditions that allow the virus to spread, the factors that allow the market economy to function normally, and the conditions that allow students to meet the immersive learning experience. Models are needed to help us think about and solve these uncertain and complex events. The principle of "Occam's razor" was proposed by philosopher William of Ockham: Pluralism must never be positioned without necessity, which is identical to the "less is more" widely circulated in the design field, and behind it, several invisible practice processes have been refined into the shortest path model for people to use.

Scott Page, an academician of the American Academy of Arts and Sciences, wrote a popular book, *The Model Thinker* (Page, 2019, p. 25–26), which mentioned seven uses of models (REDCAPE), namely reason, explain, design, communicate, act, predict, and explore.

- Reasons: To identify conditions and deduce logical implications.
- Explain: To provide (testable) explanations for empirical phenomena.
- Design: To choose features of institutions, policies, and rules.
- Communication: To relate knowledge and understanding.
- Act: To guide policy choices and strategic actions.
- Predict: To make numerical and categorical predictions of future and unknown phenomena.
- Explore: To investigate possibilities and hypotheticals.

As a result, based on the macro-level DT model from the perspective of education, this chapter will introduce and analyze the design process that the mainstream DT model at the middle level must follow, as well as compare different DT models, explain the core attributes of DT, explain the tools for the teaching application of DT model, present the personnel training elements at the micro level, and finally explore the function of DT in the development of students, teachers, and schools. We are excited about developing a future-oriented school learning community and focusing on students' future career development and life trajectory, which is closely related to DT.

4.2 Design Thinking in Education

Thinking is an intangible, but real, conscious movement embodied in the process by which the human brain generalizes and directly reacts to objective things through language and action, whereas "design" in DT refers to design in a broad sense, which is to explore people's ways of thinking and has the characteristics of creative thinking training. As a proponent of DT, Tim Brown, president and CEO of IDEO, believes that it should be an exploratory innovative thinking, with a structured course of action to meet people's needs, exploring solutions to problems, iterating the best solutions through cyclic testing, analyzing problems from three perspectives: users' needs, technical feasibility, and business sustainability, and solving uncertain and complex innovation problems. DT, as a constructivist learning method, helps to cultivate students' problem-solving ability, critical thinking ability, cooperation ability, communication ability, empathize, and social responsibility in the field of education, so that students can calmly solve complex problems in daily life and lay a solid foundation for their future growth (Qiao et al., 2020, p. 2). Meanwhile, DT can provide new methods for teaching design, new ways for teachers to improve their abilities, and new ideas for future school construction. For example, Australia has developed a "transformative interdisciplinary teaching method based on the framework of DT." The United States has carried out a project of "integrating DT into classroom teaching." The famous design company IDEO has launched a "Human-centered design."[1] Mishra and Koehler (2006) had put forward a Technological Pedagogical Content.

Knowledge (TPACK) is a framework for teachers to cultivate DT, while Laurillard further advocates teaching as a design science. These are typical examples of how DT is used in education. Currently, the application basis of DT in education is primarily derived from three learning theories: "Learning by Doing" theory, constructivist learning theory, and Creative Problem- Solving. Mastering learning theory has practical implications for improving education and teaching through DT.

4.2.1 *Learning by Doing and Design Thinking*

As a famous American educator and philosopher of the twentieth century, John Dewey is a representative of the American progressive education movement. He advocates emphasizing on the nature of the learner and promoting their individualized development, which differs from traditional teaching ideas such as "classroom-centered," "textbook-centered," and "teacher-centered." He promotes the teaching concepts of student-centeredness, activity-centeredness, and experience-centeredness. His philosophy aimed to cultivate learners' sensitivity and interest in life, enabling them to grasp true knowledge through experiential activities. Dewey

[1] http://www.designkit.org/.

famously asserted that "the essence of education is the transformation of experience." The process of seeking knowledge is as important as the knowledge itself, and "Learning by Doing" is the core teaching principle that has run through education reform for nearly a century. Dewey redefined the concept of "experience," viewing it as dynamic and ever-evolving. Consequently, the corresponding learning process became one of continuous and dynamic development, characterized by inquiry and reflection (Dewey, 1901). "Learning by Doing" should be able to answer "what is the learner's interest," "what should the learner do" and "how should the learner do." This pedagogical approach constitutes a "practical process" of teaching. Knowledge and experience interact between subject and object, making knowledge acquisition in schools closely related to students' lives. Dewey believes that schools should take on the characteristics of a "small society" and learn from activities that are truly educational and interesting. This includes establishing laboratories, creative workshops, factories, and more ("Creating Situations" in design thinking). Students are encouraged to immerse themselves in activities that capture their interest. Throughout these activities, students embark on a journey to solve real-world problems ("Defining Problems" in design thinking) by conducting research, proposing hypotheses for problem resolution ("Generating Hypotheses" in design thinking), testing these hypotheses within the activity itself ("Prototyping Solutions" in design thinking), and drawing conclusions based on the success or failure of their hypotheses ("Testing Hypotheses" in design thinking). This encompasses the five-step teaching method known as "Learning by Doing."

> As educators, we must consider some critical questions. Will our learners remember performing the play *The Odyssey* for the student body? Will they remember the campaign undertaken to clean a local reservoir fouled with pollution? Will they remember the Skype interview they conducted with an astronaut from NASA, or a Pulitzer Prize-winning author, or a local politician explaining some of the important issues their town is currently facing? Or will they remember the countless hours of worksheets and homework you assigned as busy-work? Will they remember the content of days upon days of standardized tests they endured before they graduated? Will they remember the content of the hundreds of stand-and-deliver lectures they received during their time in school? How many schoolteachers have ever had a former student return and tell them a question from a standardized test changed his or her life? (Jukes & Schaaf, 2019)

"Learning by Doing" aligns seamlessly with the DT process, both emphasizing starting from the situation and real problems, exploring problem clues, and constantly verifying them in practice. Dewey's teaching approach underscores the need for learners to cultivate empathy, guide them toward proactive learning behaviors during activities, and subsequently adapt teaching methods to suit each learner's aptitude.

4.2.2 Constructivism Learning Theory and Design Thinking

Constructivism evolved from Jean Piaget's theory of children's cognitive development, which gained popularity in the 1980s. Constructivism holds that "knowledge" is not acquired by teachers, but rather by learners learning within a specific social and cultural context. During this process, learners can seek assistance from various sources, such as teachers, learning partners, and learning materials, as well as engage in interpersonal collaborative activities to construct meaningful understanding. Constructivism emphasizes the active role of learners, their initiative, social interactions, and contextual factors. Firstly, learning is a psychological representation process in which students actively construct meaning by using previously known methods rather than passively accepting existing knowledge, which can promote the development of students' inquiry ability and creativity. Secondly, constructivism holds that the learning process can manifest itself not only as individual behavior but also as social activities. Each learner is limited by their existing knowledge and experiences, potentially leading to blind spots in their understanding. As a result, constructivism holds that the process of internal change in an individual's cognitive structure requires external stimulus and that it is critical to actively select, process, and integrate external information in order to promote self-growth. Thirdly, constructivism emphasizes that valuable learning should take place within authentic learning needs and tasks. It underscores the constructive nature of knowledge, suggesting that knowledge should be "invented" or constructed based on these authentic experiences. As a result, constructivism learning theory holds that the four elements of meaningful learning are "situation," "collaboration," "conversation," and "meaning construction."

4.2.2.1 Situation

Constructivism emphasizes that learning behavior is closely related to social and cultural background, and learning in real-world situations enables learners to assimilate and index the new knowledge they have learned, giving new knowledge a specific meaning. When existing experiences cannot accommodate new information, a process of transformation and reorganization is triggered. In contrast to traditional teaching approaches that often lack the dynamic and immersive characteristics of real-world situations, constructivism advocates a teaching design that prioritizes the creation of contexts conducive to students' meaningful construction of knowledge, rather than starting with predefined teaching objectives. In traditional classroom settings, the absence of these dynamic elements can pose difficulties for learners in constructing the meaning of knowledge, and the delays between each feedback instance can impede the learning process. Constructivism places a strong emphasis on student-centeredness, encouraging students to exhibit initiative, apply their acquired knowledge and skills in diverse contexts, adjust their actions based on their understanding of the subject matter, and engage in self-feedback mechanisms.

4.2.2.2 Collaboration

One of the core constructivist viewpoints is to pay attention to the interaction between learners and their surroundings, with collaboration being integral to the entire learning process. This collaboration extends to interactions between teachers and students, as well as among students themselves. Under the supervision of teachers, students form cooperative relationships with their peers. Together, they examine theoretical materials, viewpoints, and hypotheses, engaging in negotiation, validation, and critical thinking. During this process, learners assume active roles as participants in the teaching activities and as builders of knowledge. They develop new cognitive processing strategies, which sets this learning approach apart from traditional teaching methods by requiring learners to take on greater self-management responsibilities. Through collaborative learning processes, the collective wisdom and thinking of the learner group, comprising both teachers and students, are shared. This signifies that the entire learning community collaboratively constructs the meaning of what they have learned, rather than each individual constructing knowledge in isolation. This process is characterized by its concentration, dynamism, and group-centered nature.

4.2.2.3 Conversation

Conversation is an indispensable and vital action in the teamwork process. Constructivism emphasizes the ability of learners to complete prescribed learning tasks in order to achieve the goal of meaning construction by communicating with peers, teachers, and other stakeholders in the social and cultural context. Learners must consider how to seek guidance and assistance from others in real time during this process. Conversation is accompanied by collaboration and a sense of community, and each learner's ideas are shared within the entire learning community. Through conversation, learners engage in critical thinking, reflect on the content they have learned, and are inspired to independently solve problems.

4.2.2.4 Meaning Construction

The ultimate goal of instruction is to facilitate meaning construction. The definition of construction refers to the understanding of the nature, laws, and inherent relationships among objects and concepts. During the teaching and learning process, learners develop a profound comprehension of the essence, patterns, and relationships inherent in the subject matter, forming a cognitive structure of the content. Learners, as the active agents of learning, acquire knowledge based on their ability to construct relevant knowledge through their experiences and interactions, rather than relying solely on memory or rote memorization. Each instance of learners assimilating and adapting to new information subtly influences the process of meaning construction. DT, as a constructivist teaching method, fundamentally encourages learners to enhance their problem-solving awareness through critical thinking, conversation, and collaboration. It empowers them to address real-life problems, thereby fostering the development of complex problem-solving approaches. This approach represents an active and engaged psychological representation process. For instance, one prominent teaching method rooted in constructivist learning theory is Anchored Instruction, also known as "problem-based teaching" or "situational teaching." It comprises the following components.

(1) **Situation Creation**: This involves enabling learning to take place in situations that closely resemble or align with real-life scenarios. (Corresponding to "empathize" in DT)
(2) **Problem Identification**: Teachers provide learners with authentic, open-ended, and engaging events closely related to the current learning topic, events that lack a single definitive answer. These events, or "anchors," serve as the core content of the learning experience. (Corresponding to "problem definition" in DT)
(3) **Self-Directed Learning**: Teachers do not directly instruct learners on how to solve problems. Instead, they assume the role of guides, offering relevant hints and consciously guiding students to engage in self-directed exploration and learning. (Corresponding to "exploring ideas" in DT)
(4) **Collaborative Learning**: Learners engage in communication, discussions, and critical thinking, sharing diverse perspectives, supplementing core issues, and organizing systematic problem-solving approaches. Through collaboration, they deepen their cognitive capabilities. (Corresponding to "prototype practice" in DT)
(5) **Formative Assessment**: Throughout this process, educators observe and record students' performances, typically in the form of formative assessments. These assessments aim to continually guide learners in acquiring knowledge, actively participating in learning activities, constructing their own knowledge repositories, showcasing their learning achievements through various means, and engaging in reflective practices. Formative assessments can take various forms, such as classroom feedback, learner portfolios, written records, journals, performance evaluations, and more. (Corresponding to "effect evaluation" in DT).

With the integration of constructivism into DT and education, the traditional emphasis on "how teachers teach" has transitioned to "how students learn," with educators assuming the role of facilitators and guides for learners. DT is progressively finding applications in a diverse array of fields, including engineering education, medical education, and business education. For instance, in the domain of instructional system design theory, concepts and methods from various disciplines such as systems engineering and psychology are amalgamated. Teaching design methodologies represented by models like ADDIE (Analysis-Design-Development-Implementation-Evaluation) are gradually evolving and being refined. These approaches are employed to nurture learners' capacity to tackle intricate problems and enhance their critical thinking skills.

4.2.3 Creative Problem-Solving (CPS) and Design Thinking

There are two types of "problems": well-structured and poorly structured. Well-structured questions frequently have a correct answer as well as a specific solution to the problem, while poorly structured problems have multiple acceptable answers and no single method for solving them. "Problem-solving" refers to the application of existing knowledge, skills, or strategies to solve problems, whereas Creative Problem-Solving (CPS) involves using systematic thinking methods, emphasizing that problem solvers should generate as many diverse solutions as possible before selecting or implementing solutions (Qiao et al., 2020). Traditional problem-solving requires only memory and association, whereas Creative problem-solving encompasses changes in psychological characteristics, problem reconstruction, and the representation of meaning (Chen, 1999). The development and refinement of "problem-solving" are characterized by open-ended problems, divergent solutions, diverse goals, and collaborative learning aspects in creative problem-solving.

In the mid-1960s, Parnes developed the CPS Model, which requires the use of divergent and convergent thinking to solve problems. It can be improved by incorporating various innovative tools and technologies at various stages of the process, consisting of five stages: discovering facts (examining and analyzing problem scenarios based on various data and information), identifying problems (stating the problems), generating ideas (using divergent and creative thinking to propose more solutions), finding solutions (selecting the best solution by using evaluation criteria), and accepting solutions (implementing actions). As a result, the CPS Model is appropriate for solving complex problems.

DT, as a creative problem-solving method, consists of three stages: inspiration, ideation, and implementation (Brown, 2019). First, the problem-solving process is more adaptable, nonlinear, and dynamic. Second, DT integrates divergent and convergent thinking. Third, DT emphasizes understanding problems in situations, expanding thinking, and validating ideas. The CPS Model, for example, which is most commonly applied in curriculum design, divides Creative Problem-Solving into three components (Isaksen & Treffinger, 1985).

(1) **Exploring the Challenge**: This component involves Objective Finding (also called Constructing Opportunities), Fact Finding (Exploring Data), and Problem Finding (Framing Problems). When confronted with difficulties or challenges, individuals or groups must understand the definition, structure, and direction of the problems at hand. (This stage, which corresponds to the inspiration stage of DT, is the first and most critical stage of DT, with the goal of identifying and describing the problems to be solved.)

(2) **Generating ideas**: This component involves inspiring ideas and finding solutions. In this stage, individuals think about the problems that have been understood and defined, use divergent thinking to propose as many solutions as possible, and then focus on these solutions using convergent thinking and displaying usable solutions. (The goal of this stage, which corresponds to the

ideation stage of DT, is to generate as many ideas as possible through techniques like brainstorming, with an emphasis on quantity rather than quality. DT emphasizes the alternate use of divergent and convergent thinking in order to improve the possibility of generating creative solutions.)

(3) **Preparing for Action**: This component involves Solution Finding (Developing Solutions) and Acceptance Finding (Building Acceptance). At this point, we must identify some feasible solutions, transform them into applicable solutions, and then put the best one into practice. (Corresponding to the last stage of DT-implementation stage, the focus of this stage is to evaluate the proposed solution and verify whether it fully solves the defined problems.)

As a result, both Creative Problem-Solving and DT place a premium on solving difficult and complex problems through a series of stages. As DT is applied in education as a Creative Problem-Solving Path, its core concepts or model operation processes serve as a reference for analyzing, reforming, and innovating educational elements to enhance learners' creative thinking and problem-solving abilities.

"Design," as a knowledge strategy holds a pivotal position in educational systems. The mastery of design knowledge directly correlates with the level of teaching awareness, teaching ability, teaching quality, and teaching management. DT encompasses not only explicit knowledge gained from books but also tacit knowledge gained through personal and team experiences. The complete manifestation of the value of DT lies in design-driven educational innovation. Design knowledge should be regarded as a necessary capital of value creation in order to promote iterative innovation and ultimately lead the reform of innovative teaching paradigms. The new knowledge gained and created through innovative educational design will be transformed into an experience, forming the distinctive "soft power" of both learners and educators. Innovative education is realized through the DT model by the common evolution of three important supporting carriers: innovative design procedures, design methods, and design teams. This chapter will continue to explain how the DT model's other essential elements work and what design tools can be used to visualize DT to empower the creative journey of education.

4.3 Design Thinking Model

> There is, however, another approach to instruction and assessment that looks at learning from a very different perspective. This approach starts with the same goal as the traditional approach, but the reasoning then heads off in a different direction. That new direction is based on the idea that schooling should help learners prepare for what they will face in life after school. Wiggins (1993) captures the thinking of this new approach to instruction by emphasizing the need for educators to provide engaging problems or questions of importance, in which learners must use their knowledge to deliver performances effectively and creatively. The tasks are similar to the problems and challenges faced by adults, consumers, or professionals in the field. (Jukes & Schaaf, 2019)

Schools must shift from being traditional content providers to cultivators of modern and future skills. We can observe that in both the education and design fields, the mention of "Design Thinking" is often followed by the application of "Design Thinking processes" and "Design Thinking models." Let us examine the contents of DT models all over the world and their implementation procedures together.

4.3.1 Classification of Design Thinking Models

D. A. Norman, a design psychology expert, divides the design methods into two generations: first-generation linear design and second-generation iterative design. Dr. D. Koberg proposed in his book in 1972 that design input requires not only analysis and synthesis but also the expansion of problem definition, the creation of ideas, and the selection and implementation of design carriers, and the spiral design program arose from this. Professor V. Kumar of the School of Design at Illinois Institute of Technology formally proposed the spiral design model in 2003, emphasizing the iterative process and cycle of design. This model follows the design process of "situation research-user research-design insight-making plan-establishing design model-implementation plan," and it is divided into two categories: "macro-DT model" and "micro-DT model." The macro-DT model refers to the overall design activity flow, which is characterized by strategic top-level planning. The R.A.C.E. (Research. Analysis. Concept. Execution) model, first proposed by a Dutch designer from the Ulm Institute of Design in 1963, is the representative DT model. The RACE model, which is known as "metadesign" internationally, begins with a linear moving path from research to action, creating a three-dimensional loop from abstraction to concreteness. It involves conducting "design analysis" based on the research results of "design input" and transforming materials into plans, instructions, and objectives. The micro-DT model refers to the process of designing activities centered on a specific link or problem. Representative DT models include the "double disamond," 3I model (Inspiration, Ideation, Implementation) model developed by IDEO Company (one of the largest design consulting companies in the world founded by Stanford University professor D. Kelley in 1991), and EDIPT model "Empathize-Define-Idea-Prototype-Test" which evolved from 3I model.

Because DT is widely used in many fields, some scholars categorize DT models into two major categories: business DT models and education DT models (Qiao et al., 2020). In the realm of business, notable DT models include 3I model (Inspiration, Ideation, Implementation) of IDEO and Google Design Sprint (GDS). Within the field of education, there are two prominent DT models: the EDIPT model developed by Hasso Plattner Institute of Design at Stanford and HPI model developed by Germany's Hasso Plattner Research Institute, which condenses the DT process into six steps: Understand, Observe, Define Point of View, Ideate, Prototype, and Test. Additionally, John Spencer, a leader in the field of DT education, introduced the widely adopted LAUNCH model (Look—Ask—Understand—Navigate—Create—Highlight) in his book *Using Design Thinking to Boost Creativity and Bring Out* *the Maker in Every Student* His approach aims to foster students' creative thinking and preparedness for the future through DT. In the following, we will go through the specific contents and implementation procedures of these four representative DT models.

4.3.2 IDEO Model (Including 3I Model and Improved Thinking Model Based on 3I)

IDEO, one of the world's largest design consulting firms, was founded in 1991 by Professor D. Kelly of Stanford University's Department of Mechanical Engineering. IDEO emphasizes that "genuine innovation" stems from a thorough understanding of the needs of target users, and promotes a "people-centered" design concept, also known as User-Centered Design. It advocates that all design activities should center on user research. For example, a university sought design advice from IDEO in order to change the learning environment of traditional classrooms (Brown et al., 2015). IDEO's focus was not on classroom design itself but on the "individuals sitting in the classroom." They excelled in "user experience design," drawing inspiration from designers' methods and tools, and incorporating "human needs" into product requirements. IDEO takes DT as its core ideology for innovative design and puts forward the 3I model, which respectively represents three stages, namely Inspiration, Ideation, and Implementation (Brown & Katz, 2009). Each stage consists of a series of iterative activities that integrate empathy, collaboration, and integrated thinking, forming a circular DT framework. The "Inspiration" stage, for example, focuses on addressing the problem domain, understanding and observing design challenges, and looking for opportunities for problem-solving. The "Ideation" stage is primarily concerned with resolution domain, employing thinking tools such as brainstorming and prototyping to consider how to transform insights into actionable creative processes. The "Implementation" stage entails translating ideas into execution paths and turning concepts into reality.

The DT process in the "3I model" is not a rigid sequence of steps, and each stage may be revisited multiple times to refine initial ideas and explore new directions. To make DT more practical in teaching, IDEO developed an improved DT model for educators, which is divided into five stages: Discovery, Interpretation, Ideation, Experimentation, and Evolution.

(1) **Discovery**: In this stage, thorough preparations are made to deeply understand the design challenges. It involves conducting user research and investigation, collecting inspiration, gaining a profound understanding of user needs, and completing the collection of inspiration and creativity multiple times, in order to lay a solid foundation for the project's smooth progress and design innovation.
(2) **Interpretation**: The collected information is transformed into actionable knowledge during this stage. It involves storytelling, meaning discovery, and framework design. Designers search for the meaning behind the surface through

"insight" and translate discovered stories into executable design opportunities. The goal is to clarify the direction for problem-solving.

(3) **Ideation**: During this stage, the designers' creativity is ignited using various design tools such as brainstorming and creative stickers. The aim is to expand their thinking without limitations. Throughout this process, ideas are continually layered, optimized, and updated, leading to an abundance of creative concepts.

(4) **Experimentation**: During this stage, designers predict and analyze the "design outcome" by creating prototypes and the Minimum Viable Products (MVPs). This helps obtain experimental feedback, enhancing designers' ability to identify space for improvement and make necessary adjustments to the problem-solving path.

(5) **Evolution**: In the final stage, a variety of evaluation criteria are used to assess the solutions generated from previous ideas. Based on the evaluation results, subsequent improvement plans, resource allocation, and iterative problem-solving paths are derived.

Meanwhile, IDEO has developed a toolkit called "Design Thinking for Educators," which provides teachers with the tools and methods needed to apply the IDEO model (Discovery, Interpretation, Ideation, Experimentation, and Evolution) in real-world scenarios, with the goal of assisting educators in designing meaningful programs in communities, schools, and classrooms.

4.3.3 EDIPT Model

In 2004, Professor D. Kelly founded d.School at Stanford University and optimized the 3I model. He proposed the famous EDIPT model (Empathize, Define, Ideate, Prototype, Test) to cultivate students' DT skills and to help students apply DT effectively throughout their project process. Each step and stage of this model includes implementation principles and corresponding methods and tools. It represents an iterative process and is currently one of the most widely used DT process models.

First, in the "Empathize" stage, we can immerse ourselves in real-life situations and truly grasp the core users' requirements by observing their behaviors, needs, and attitudes. This enables us to adopt a user-centered perspective and establish a connection. There is a significant distinction between "empathy" and "sympathy." For example, when knowing that a student's mother has recently passed away, an empathetic teacher might say, "Are you feeling sad right now? Is there anything you'd like to do?" However, a sympathetic teacher might exclaim, "Oh, you poor thing!" If you want to gain a deeper understanding of students' needs in class or to improve the teaching environment, the best way to gain empathy is to "become a student for a few more days" and experience students' needs and the world they see through their eyes.

Second, in the "Define" stage, we consolidate and refine the user needs identified during the Empathize phase. We filter out irrelevant information and create a clear list of key requirements from the collected data. Common thinking tools include user personas, POV (Point of View), empathy maps, and the BCG Matrix (four-quadrant analysis method) to make the definition of the problem detailed and precise. It's also helpful to use synonymous terms or list multiple definitions to ensure clarity and comprehensiveness. For instance, "students lack interest in the learning material" is not a well-defined problem. However, defining it as "How can we improve students' engagement in physics classes, reflected in their final grades?" provides a precise and actionable problem statement. The level of precision in problem definition directly influences the problem-solving approach, requiring a focused approach.

Third, during the "Ideate" stage, we consider how to solve the defined problem and envision the overall picture. To collect ideas, brainstorming, Six Thinking Hats, and other thinking tools are frequently used. We encourage a high quantity of ideas and maintain an open environment where ideas are judged without bias, so that all kinds of ideas can be put forward freely, allowing the team's creativity and imagination to be fully utilized. It is crucial to note that this stage isn't about finding the perfect idea right away but rather generating multiple ideas from which a few promising ones can be selected. Thus, maintaining an open and receptive attitude among team members is vital.

Fourth, in the "Prototype" stage, we use tools like creating low-fidelity prototypes, role-playing, storyboards, and sketches to visualize the creative ideas developed in the previous stage. These prototypes undergo continuous testing, optimization, and refinement to evolve into the best possible solution. During this stage, low-cost, user-friendly models are created to assess idea feasibility, enabling rapid trial-and-error and iterative improvement. Simulating real products helps validate the effectiveness of earlier creative ideas.

Fifth, in the "Test" stage, we primarily evaluate the use of our prototype for the target users in real-world scenarios. We employ thinking tools such as demonstration, the four-quadrant test, and real-world simulation testing to assess whether the addressed problems have genuinely been solved and whether the requirements have been met. This stage often reveals new issues and may lead to the redefinition of certain problems, prompting a cycle of creative ideation, prototype implementation, and testing of design objectives.

Plattner and Leif argue that while DT typically consists of five main stages in process diagrams, in practice, numerous and complicated repetitions and iterations are required. DT fosters learning by fostering a dynamic interactive environment through rapid conceptual prototypes (Chen & Huang, 2019; Plattner et al., 2010). K-12 Lab, d.School, Stanford University has collaborated with IDEO to launch a K-12-oriented project called Design Thinking in Schools (K-12). This project divided K-12 into four stages based on the EDIPT model, constructed the goal and ability level of the DT link K-12, and designed corresponding activities in each link based on different levels.[2] The project collaborates with a variety of educational innovators, including teachers, school leaders, learning experience designers, and technology

[2] https://www.designthinkinginschools.com/.

entrepreneurs, with the goal of incorporating DT into teaching and learning, cultivating the creative confidence of all educators and students, and striving to provide opportunities for every child to become an innovator.

4.3.4 HPI Model

Hasso Plattner Institute of Potsdam University (HPI d.School) built upon the d.School model and put forward the HPI model of DT, which consists of six stages: Understand, Observe, Define Point of View, Ideate, Prototype, and Test (Wang et al., 2017). This model serves as a guide for designers in practical DT endeavors.

To begin, the process begins with understanding, analyzing and defining the problems that users need to solve. This involves asking questions, gathering data, and establishing clear design challenges and preliminary design goals. Following this, the Observe phase entails collecting multidimensional information about the target users through methods like experiential research and user interviews, which aids in the integration of user needs. Subsequently, using tools like empathy maps, designers identify specific user needs and narrow them down to 1–2 core design challenges. Once the design challenges are defined, the Ideate phase begins. Creative methods, flip propositions, and other brainstorming techniques are employed for team collaboration to conceive and document various creative solutions. Afterward, ideas that are deemed suitable for further development into prototypes are selected. In the Prototype stage, role-playing, high- and low-fidelity prototypes, and other tools are utilized to externalize creative ideas. Finally, the Testing stage involves continuous optimization, and refinement of the prototypes, ultimately leading to the best possible solution.

The most important step in this process lies in the first stage, which involves understanding and observing user needs and making them explicit. User needs can be categorized into two main types: explicit needs and implicit needs. Explicit needs are specific requirements that users can express, which are comprehensive and multidimensional. Common methods for eliciting explicit needs include questionnaire surveys, which can take various forms such as yes–no questions, multiple-choice questions, ranking questions, and rating questions to uncover the explicit needs of target users.

On the other hand, implicit needs refer to the latent demands that arise during the use of a product. These needs are often unexpressed by users and may not even have been considered as design requirements. Quantitative research or standard questionnaires are typically ineffective in detecting these implicit needs. However, they can be recorded through qualitative research methods such as observation, in-depth interviews, and grounded theory. These approaches help unveil the hidden or unspoken requirements that users may have.

In 2003, professors V. Kumar and P. Whitney from the Illinois Institute of Technology introduced the theory of Activity-focused Research as a theoretical foundation for studying these implicit user needs. This theory involves a deep exploration of the "invisible needs" by observing and documenting user behaviors in specific contexts and environments. It has been widely adopted by experts in the field of education for innovative activities (Zhang, 2021).

4.3.5 LAUNCH Model

John Spencer, a pioneer in the field of creativity training and DT education in the United States, is dedicated to teaching students to think creatively through DT. He was also invited to speak about future learning at the White House's "Preparing for the Future" summit, leaving a profound impact on the field of design education. The LAUNCH model of applied DT is presented in his book *LAUNCH: Using Design Thinking to Boost Creativity and Bring Out the Maker in Every Student*. This is a revolutionary approach to organizing courses and teaching methods (Spencer & Juliani, 2016), as well as a set of scientific methodologies that has quickly become popular in universities around the world, leading to significant transformations in teaching and learning. The LAUNCH model consists of the seven stages listed below.

The first stage is to look, listen, and learn. The LAUNCH cycle begins with students observing problems, listening to other people's ideas, and grasping key concepts in a specific science or engineering. This stage encourages students to naturally engage with a set of challenges faced by a specific group. Guided by teachers through questioning, students' cognitive abilities are progressively enhanced as they ponder these challenges. Interviews, needs assessments, and observation can help students discover and explore.

The second stage is to ask lots of questions. After students conduct an in-depth cognitive exploration of the problem, they naturally generate numerous questions, sparking their curiosity. They can then pinpoint a specific problem with the help of teachers organizing brainstorming sessions and preparing a list of sentences and keywords that describe the problem in detail. In this stage, the teacher should guide students in asking scientific questions.

The third stage is to understand the problem or process. Once the questions are posed, the students begin their research. They will know the key information related to the problem, explore causal relationships, conduct research on competing products, and gather more information.

The fourth stage is to navigate ideas. During this stage, multiple small iterative cycles can be initiated. Students begin with brainstorming and then analyze each idea separately. They engage in collaborative communication within the team and return to brainstorming collectively. This allows students to pool their ideas until a comprehensive plan is developed. After this stage, students will have a relatively clear concept and idea of what they "want to create."

The fifth stage is to create. Students are assisted in building a prototype, which could range from a draft of an electronic magazine to an electronic game created using tools like Scratch, a children's programming tool developed by MIT, or even physical models made from cardboard or hand-drawn sketches. In essence, this stage involves hands-on work to transform ideas into tangible products.

The sixth stage is to highlight what's working and failing. This is an iterative phase where students identify the strengths and weaknesses of their product prototypes and continually address any issue. Students need to have a clear understanding of both the quality standards their product should meet and how to assess. After multiple iterations, when the prototype meets the expected standards, it moves on to the product release stage.

The seventh stage is product launch. Students present their products to real-world audiences and persuade them of the importance of their design. Feedback from target users enhances students' understanding of their "creative works" According to the feedback, they can develop the next version by re-starting the LAUNCH cycle.

The seven steps of the LAUNCH model seem complicated and time-consuming at first glance, but they actually help save time in the long run by ensuring that the initial research is thorough. In fact, without adequate research in the beginning, more time would be wasted in the later execution stages, potentially leading to the need to start over.

The LAUNCH model of design thinking is particularly well-suited for the following scenarios, as confirmed through extensive case studies and practical research: (1) When students are involved in creating tangible products. (2) When students are tasked with large-scale projects. (3) When the teacher is in command (with effective communication with other stakeholders such as students' parents and school administrators). (4) When the specific problems students are addressing hold great importance to them. In such cases, the LAUNCH model can effectively break down complex problems and assist students in completing the creative process.

4.3.6 A Comparison of Design Thinking Models

The analysis of the above models reveals that the DT model is iterative in nature and has some similarities. The IDEO model is provided to teachers in order to improve teaching design, emphasizing that the process of design is the process of exploration, which provides effective ideas for assisting teachers in carrying out creative teaching activities. The EDIPT model at d.School emphasizes a user-centered approach, iteration, experience, and collaboration. The HPI model focuses on learners' problem-solving skills and uses design tools to guide their best practices. The LAUNCH model is aimed at the teaching and learning process and is appropriate for any class, subject, or student, assisting students in developing their thinking, creativity, and inner "maker" capabilities while acquiring knowledge.

These models may seem complicated and lengthy, but they share common elements. Each model provides a systematic thinking framework for project designers, with clear processes and key action points in stages such as identifying needs, defining problems, gathering inspiration, organizing ideas, designing solutions, hands-on creation, and testing and sharing. These frameworks help designers

Model	Execution flow	Characteristic	Applied perspective
3I model of IDEO	Inspiration-Ideation-Implementation	It is emphasized that design is a process of exploration, and the three stages are constantly overlapping and repeated, and cyclic iteration is carried out.	All the people
IDEO DT improvement model	Discovery-Interpretation-Ideation-Experimentation-Evolution	It is emphasized that design should return to "people" itself, focus on people's needs, and create clarity from complexity.	Enterprise manager
EDIPT model	Empathize-Define-Ideate-Prototype-Test	Design should be regarded as a process, emphasizing open thinking, focusing on establishing a problem-solving system from fuzziness, and emphasizing cooperation and output.	Educators, students, enterprise managers
HPI model	Understand-Observe-Define Point of View-Ideate-Prototype-Test	Emphasize the problem-solving of learners, use design tools to guide best practices and gain experience and experience.	Educators, students, enterprise managers
LAUNCH model	Look, listen, and learn-Ask lots of questions-Understand the problem or process-Navigate ideas-Create-Highlight what's working and failing-Publish	Emphasize the cultivation of curiosity, independent construction and open thinking, and encourage teamwork of different disciplines and ages.	Educators, students

Fig. 4.1 Comparison of DT models

externalize their thinking, guide best practices, and address real-world problems. The comparison of these design thinking models is depicted in Fig. 4.1.

When we compare different DT models, we can see that DT prioritizes three elements: people, place, and process (Hillen & Lévy, 2013). "People" refers to breaking the constraints of single thinking and advancing the Creative Problem-Solving perspective through collaboration among project team members or collaboration of people with interdisciplinary backgrounds, which is also the potential of DT and continuous innovation. The concept of "place" refers to the need for open and free environmental support of both the generation of creative ideas and project progress. From the layout of the space to the design tools, everything should be flexible and inclusive so that every team member is proactive and in a good mood. "Process" implies that DT must follow a specific execution process, similar to the "steps" of each model mentioned above, but in practice, the DT process can be parallel, even repeated and iterative, and each step can be repeated to form the best solution.

4.4 Tools to Support the Design Process

Each step in the DT model necessitates the use of corresponding thinking tools to make "creativity" explicit and to assist designers in transforming ideas in their heads into visible, practical, and valuable content. In this case, tools to support the design process are especially important. In the early stages of a project, when exploration and discovery are required, questionnaires, interviews, Cultural Probes, and user portraits are frequently used. During the stage of understanding and defining problems, the empathy map method, User Experience Maps method, and POV method are commonly used. During the creative development stage, brainstorming and the Six Thinking Hats are frequently used. During the prototyping stage, renderings and software prototyping are frequently used. During the testing and evaluation stage, usability testing and design evaluation methods are frequently used. The methods of these DT tools can effectively support our activity design. It is hoped that by mastering these tools, teachers will be able to choose with greater flexibility to guide their teaching practice. Let's now look more closely at the tools to support the design process that corresponds to the general design process steps and their specific use processes.

4.4.1 Tools for "Exploration and Discovery"

4.4.1.1 Questionnaire Method

Questionnaire surveys are frequently used in the field of design to determine target users' attitudes and behavior intentions. Despite factors like the subjective influence of investigators, the number of questionnaire samples, and the quality of return visits, the questionnaire method can survey a large number of target users in a short period of time and its data can be analyzed quantitatively, which is directional when solving certain categories of problems. The questionnaire includes not only basic information about the target users (such as age, gender, occupation, and income) but also open-ended and closed-ended questions. To avoid filling out invalid questionnaires due to fatigue, the total number of questionnaire questions should not be excessive. Less than a quarter for answering the whole questionnaire is suggested. There are no consistent answers to open-ended questions, such as "What do you think of students' frequent overuse of electronic devices in class? Please enter any relevant content." Closed questions include multiple-choice and matrix questions. Multiple-choice questions are classified into two types: two-choice questions and questions with more choices, which direct users to provide "either-or" or "multiple-range answers," and respondents choose based on the limits of the answers. Matrix questions are made by grouping questions from the same category and sharing the same set of answers. When designing answers, we frequently use the Likert Five-Point Scale, which is divided into five levels: "very agree, basically agree, general, basically disagree, and very disagree." When the questionnaire is finished, it can be distributed on a small scale to experts and typical investigators to see if the design is clear and accurate enough, and then it can be distributed on a large scale if there is no problem. Before beginning quantitative analysis, the total sample number, sampling accuracy, effectiveness, and other values must be confirmed after the questionnaire has been collected.

4.4.1.2 Interview Method

The interview method refers to the method by which researchers collect information and materials after communicating and conversing with the research objects, and sort out the key information needed to guide the design direction. The interview method can be used to conduct group interviews by organizing focus groups, or it can be used to conduct in-depth interviews with interviewees to explore their subjective understanding of key issues and phenomena. Structured interviews and non-structured interviews are the two types of interviews. A structured interview is one in which all interviewees are asked the same set of questions in the same order and are treated uniformly. A non-structured interview is a flexible, personalized, and in-depth interview in which the interviewee's experience, ideas, and evaluation are detected through "small talk" that naturally cuts into the research question. The interviewer should follow the interviewee's perspective and ask different questions from person to person during the interview process. The goal of the interview is to create a portrait model of future users, understand the demand points for products to be developed, comprehend the design tasks, assist the project in perceiving the pain points that must be addressed in design, and consider the design direction. Selecting interviewees, writing outlines, conducting small-scale test interviews, conducting formal interviews, analyzing interviewed data, and establishing product improvement directions based on the interviewed data are all common processes in interviews.

4.4.1.3 Cultural Probes

Cultural Probes was proposed by Gaver, Dunne, and Pacenti in 1999 (Gaver et al., 1999). They were inspired by the art movement "Situationist International." (Situationist International is an international organization of avant-garde artists, intellectuals, and political theorists.) Instead of using the scientific method, it employs the artistic method, which is characterized by being uncontrollable and receiving inspiration. Cultural Probes is a tool for stimulating creativity in the design process and collecting inspiration data about people's lives, values, and ideas. These detectors can be small software packages, or they can contain any type of object or device (such as maps, postcards, cameras, or diaries), as well as memorable tasks, which will be provided to participants in order for them to record specific events, feelings, or interactions. Its goal is to inspire people to better understand their culture, ideas, and values, thereby stimulating the imagination of designers. The basic process of Cultural Probes is as follows: design the Cultural Probes toolkit, select the target user group, outline the activities to the target user group, and provide them with the corresponding toolkit to complete the activities in a limited time, collect materials, and analyze them. For example, in the project "K-12 group classroom creative development and design," the teacher first assigns tasks and questions to students based on the courses and activities to be developed and then discusses and designs the material composition in the Cultural Probes package, which could include cameras, maps, diaries, inspiration cards, and so on. Then, it is specified that students use these probe tools to complete self-exploration of courses and activities within a limited time, and finally, teachers should guide students to collect and analyze the recorded information.

4.4.2 *Tools for "Insights and Defining Problems"*

4.4.2.1 Empathy Map

Empathy map is the core of "human-centered" design, providing teachers with a classification method of students' behaviors, attitudes, and portraits obtained during sorting out and observing, and can be analyzed based on "what students said, heard, and did," paying attention to students' behaviors, and at the same time, deeply understanding students' experience and emotional changes, such as "what students think and feel," and so on. Teachers can immerse themselves in their students' "scene" by using the empathy map method. What students feel, do, say, and think are marked respectively in the four quadrants of the empathy map to help teachers understand students' pain points and inspire them to capture design challenges (opportunities). A quadrant diagram of this type can not only be created quickly but it can also be iterated and revised quickly. With such an empathy map, we can identify problems and obstacles students face from their perspective and consider corresponding teaching design opportunities.

4.4.2.2 User Experience Maps

User Experience Maps, also known as user journey maps, draw a picture and label several dimensions (stage, behavior, contact point, feeling, pain point, and opportunity point) to assist designers in analyzing the process of introducing target users' products and services to the market through storytelling. Based on this, we can understand their behaviors, needs, preferences, and pain points. It is a design tool used to sort out user scenarios and experience issues. Similar to using a scalpel, we begin by horizontally analyzing a demand based on the target user's behavior, and then we vertically analyze each behavior node. This is a simple tool for presentation that allows us to emphasize the most important points. For instance, if our design theme is "How to improve online student participation through the course of history of science," creating User Experience Maps comprises four stages. The first stage is to get close to the scene. Teachers select students first, then set the stage for online courses and "record events" from the perspective of "users." In the second stage, on-site observation records are needed. Collect procedural information by observing students' behavioral reactions, emotional reactions, and interactive reactions while they are watching the course online. The third stage is the organization of information. The observed information, words, pictures, videos, and other materials are thoroughly organized, and various "contact points" are extracted from the stages of "students' preparation before class," "performance during class," and "behavior of feedback after class," including information contact and operation contact. The information contact refers to the words and images with which students come into contact, whereas the operation contact refers to the behavior button, equipment, and platform with which students interact. Create a "journey map of students' online courses" in the fourth stage. Analyze the students' behaviors and emotions at all stages to identify design opportunities. We can learn the core needs of designing the project "How to improve online student participation through the course of the history of science" by observing different stages of behavior, contacts, and emotional feedback, and developing the corresponding "function points of student needs" to guide teachers' teaching design.

4.4.2.3 Point of View

Point of view is a concise and feasible problem statement tool after exploring the needs of target users and analyzing innovation opportunities, which includes three elements: user, need, and insight. The usual presentation sentence is: (What kind of) users need (… verbs) because (… concrete description) is very important to them, and it can also be expressed as: (users) need (users' needs) because (insights) are very important to him. For example, when we received a demand from a mother: "What should I do if my child does not study hard during the period of online courses? Even if I work online at home, I have no time to look after him." The role of POV is to retell it clearly, complete the context, and make everyone understand it. It needs to describe three things: (1) Who: First we need to describe "who has this problem" before giving him advice, right? (2) Need or pain point: describe the demand. (3) Insight: Describe a story and give more background information. We can try to fill in:

User: The mother of a fourth-grade child.

Need: She hopes she doesn't have to worry much during pandemic and the child's ranking remains the top 1/3 in his class.

So that: The parent doesn't have to spend much time worrying about her child's study and she has more time for work and life.

Insight: Due to the tight work, she has less time to look after her child. The child often uses the Internet and mobile phones to play games, which leads to a decline in performance.

We can simplify the description above as POV: the mother (needs) a way to keep the child's academic performance from declining when taking online courses during the epidemic, (because) there is no time to care about the child's study, (so that) the parent can spare more time for work and family care. It should be noted that, once the problem has been focused on, the smaller the problem is, the easier it is to solve. It can be presented in the form of exhibition boards, analyzing environmental factors, stating design problems, clarifying user needs, giving insight and thinking, putting forward design assumptions, determining design goals, and design significance, in order to state the problems more clearly (Qiao et al., 2020).

4.4.3 *Tools for "Creative Development"*

4.4.3.1 Brainstorming

Brainstorming is a technique used to gain inspiration, boost creativity, and identify problems, pain points, and solutions. People from various professional backgrounds are brought together to brainstorm and search for new tools. Teachers frequently guide students in freely expressing their opinions on a given topic while remaining open, not refuting, and eager to question and evaluate. Brainstorming emphasizes the method of stimulating each participant to generate a large number of ideas while remaining free and relaxed, encourages whimsy and free speech, and prioritizes quantity over quality of ideas. The greater the number, the more likely it is that good ideas will emerge. At the same time, the session's host cannot pass judgment, and team members can make new suggestions for other people's ideas as well as synthesize multiple ideas. Brainstorming techniques include speaking, writing, drawing, and posting. (1) Design the theme, expand the problem's core keywords, encourage on-the-spot participants to speak freely through discussion, and select the keywords and directions of the best idea or scheme. (2) When using the silent brainstorming method, each time six people must participate, and each participant must write three creative points on paper. Each creative round like this lasts 5 min, for a total of 6 rounds. Finally, using scissors, these concepts are cut out and classified. User needs, application environment, theme, design purpose, user behavior, and user interest are the classification dimensions that can be summarized. (3) In the form of sketching, the theme (trunk) and creative points (branches) are combined, and the keywords corresponding to the core are marked and then classified. (4) Role-playing can be used to stimulate participants' creative thinking. For example, when designing an intelligent classroom environment, you can dress up as a student for role-playing. With props, you can deeply experience the feeling of being a student in various classrooms, different times, and courses, record the demand points and corresponding creative points generated in this process, and restore the environment in which future products will be located as much as possible so that you can be in it.

4.4.3.2 Six Thinking Hats

Dr. Edward de Bono, the "father of innovative thinking" and the "founder of changing human thinking mode in the twentieth century," developed the Six Thinking Hats thinking training model. "The biggest problem in thinking is chaos," he once said, "and we always try to solve too many problems at once." Six Thinking Hats provides a "parallel thinking" tool to help you avoid wasting time arguing with each other. The emphasis is on "what can be" rather than "what it is itself," and the goal is to find a way forward rather than argue about who is right or wrong. Using Six Thinking Hats will clarify chaotic thinking, transform meaningless group arguments into brainstorming creations, and inspire everyone to be creative.

Six Thinking Hats refers to the use of six different colors of hats to represent six different modes of thinking. The blue hat is in charge of “managing the whole process of thinking” and blue hat thinkers should arrange the order of thinking and apportion time for thinking. The red hat is in charge of “intuition and the feeling of thinking.” People wearing a red thinking hat solve emotional problems. They can express their emotions, as well as their intuition, feelings, hunches, and other points of view. The yellow thinking hat is in charge of “thinking about the value and benefits of the problem” as it represents value and affirmation. People wearing yellow thinking hat approach problems from the front and express optimistic, hopeful, and constructive viewpoints. “Creative points and new ideas” are the responsibility of the green hat, which represents greenery and vitality. The green thinking hat represents imagination and creativity and enables creative thinking, brainstorming, and different ways of thinking. The white hat is in charge of “providing thinking information and data” as white represents neutrality and objectivity. People pay attention to objective facts and data while wearing a white thinking hat. The black hat is in charge of “risks and difficulties in realization.” While wearing a black thinking hat, people can use negative, doubtful, and questioning views to criticize logically, express negative opinions, and discover logical errors (Wang, 2015).

The key to using Six Thinking Hats is how users arrange the order of the hats, or how we organize our thinking. We can truly master the Six Thinking Hats application method only if we master the process of weaving thinking. First and foremost, it should be clear whether the discussion’s goal is to assess creativity or to make a product decision. If you need to design a decision, first “put on” the blue hat to manage the thought process, then the white hat to obtain and sort out the known information, the yellow hat to sort out the plan’s positive factors, the black hat to sort out the crisis and risk points, the green hat to put forward the innovation points, and finally the blue hat to implement the action plan. Six Thinking Hats can be used to create both individually and in groups.

4.4.4 Tools for “Prototype”

4.4.4.1 Effect Diagrams

Designers create the effect diagrams with painting tools such as pencils, markers, colored pens, and cardboard, and the creative content is transformed into a visual effect diagram using painting skills and drawing principles. The most common ones are scheme effect diagrams, function display diagrams, and three views. Scheme effect diagrams are effect diagrams that are created to inspire further creative inspiration, aid communication, and discuss schemes. In general, functional display drawings must depict the structure, materials, mechanism, and local details of a product. To create effect diagrams, three views are primarily used: main view, left view, and top view, which allows everyone to have a sense of space. Hand-painted effect diagrams are typically dependent on the designers’ long-term hand-painted ability and necessitate a solid painting foundation. Effect diagrams can also refer to high-simulation virtual images that use computer three-dimensional simulation software technology to simulate the real world. To model and render the design content in space, 3D MAX, MAYA, CAD, SAI, Rhino, and other software are used for a more realistic effect diagram.

4.4.4.2 Prototyping

The "prototype" is an effective tool in DT for explicit communication between designers and users. It is appropriate for determining whether the designed content is feasible, making it easy to test and verify later. The prototype has the following characteristics: (1) It prioritizes speed and efficiency over refinement, allowing the team to quickly validate new ideas and identify opportunities. (2) The prototype must be iterated, and it materializes the idea. When a new function or service point emerges, it will be reflected in the new prototype, and the iterative and trial-and-error process will continue. (3) A prototype has no need to be perfect. Not representing the final product, it is simply a way to externalize "thinking" in order to improve team communication and predict future directions. The prototype can be displayed using conceptual materials (Lego, clay, plush strips, cardboard, etc.), or intelligent hardware (intelligent materials, various engineering hardware), or an experiential prototype to create a real situation, allowing users to participate in it in a "personal experience" manner. For example, when students are asked "how to design the blind path area on campus," they can be blindfolded and walk around various scenes on campus. Recording devices might be used to note down all their feelings and needs during this process. When the design is almost completed, these students can experience the "designed blind path" themselves again to see if it meets their expectations. Furthermore, we can use computer software to create high-fidelity prototypes, which primarily show the target users' user interface, interactive logic, and visual effects when using electronic devices, and assist designers in simulating the product appearance as much as possible. This type of software typically aids the team in creating and cooperating, as well as iterative modification using the software after receiving timely feedback. Prototyping software commonly used includes Axure, Sketch, Figma, Mockitt, and others.

4.4.5 Tools for "Test and Evaluation"

4.4.5.1 Usability Test

Usability is a fundamental characteristic of products and services after they are designed, and it is reflected in the interaction between products and target users. Usability is an important quality index of interactive IT products and systems that refers to the degree to which products are effective, easy to learn, efficient, easy to remember, with fewer mistakes, and satisfactory to users, that is, whether users can complete their tasks with the products, how efficient they are, and how they feel subjectively, which is actually the product quality from the user's perspective, the core of the product competitiveness. Usability is defined by ISO 9241-11-1998 as a product's effectiveness, efficiency, and satisfaction when used for a specific purpose by a specific user in specific use. The following are the most common tools to evaluate usability: (1) questionnaire and interview. (2) Use smart devices to record the user's emotions, attitudes, expressions, and data of other dimensions digitally. (3) As wearable smart devices and the Internet of Things evolve, we can use intelligent terminals to collect users' behavior, skin data, and physiological data to test their psychological state, action capture, and behavior information. With the advancement of intelligent technology, devices such as brainwave instrument, eye tracker, depth-of-field camera, and smart glasses are increasingly being used in usability testing, allowing real-world application data from users to be collected and analyzed for iterative improvement of design direction.

4.4.5.2 Design Evaluation

Design evaluation is the process of comparing and judging the generated design schemes in order to determine the worth of each scheme and weigh its advantages and disadvantages in order to select the best design scheme. There are typically two approaches to design evaluation: first, based on the subject of evaluation, design evaluation can be divided into dimensions including applicability, functionality, aesthetics, safety, contemporaneity, social value, and environmental impact. Second, it is classified into quantitative and qualitative evaluations based on the nature of the evaluation. The term qualitative evaluation refers to non-quantitative evaluation dimensions such as comfort, aesthetics, and creativity, whereas quantitative evaluation refers to the evaluation of cost, technology, and other quantifiable contents. There are various evaluation methods for quantitative evaluation. (1) Radar diagram method, which scores all attribute values of created products based on coordinates and scores them from 1 to 5. The larger the enclosed space surrounded by five attributes, the higher the design's score in the five attribute standards, and the greater the certainty of its design value. (2) Use the "point evaluation method" to make a rough assessment of each scheme item by item, with mark "+" for meeting the requirements, mark "−" for failing to meet the requirements, and "?" for further discussion needed, using "!" for re-examining needed. Evaluate it one by one in terms of whether meeting the needs of function, cost, humanity, environmental protection, aesthetic appearance, and sense of contemporaneity. The typical scoring method procedure is to determine the evaluation index, establish the evaluation index coefficient, choose the scoring standard, determine the scoring requirements, score each evaluation index, select the total score scoring method, count the total score, and choose the scheme with the highest score as the best.

4.5 Conclusion

It can be observed that Design Thinking (DT) is increasingly being applied in the field of education. As the World Economic Forum proposed in 2015, regardless of the level of education, a person's lifelong learning skills, such as critical thinking, problem-solving ability, creativity, communication, and collaboration ability, are receiving increasing attention from society. "We must always pay attention to DT innovation in education" (Song & Ryu, 2022). In a trend study, the summary research on DT related to teaching revealed a steady growth trend after 2015 and an explosive growth trend in 2020, indicating that in the fourth industrial revolution era, the education system, including universities, was thinking about how to develop and improve the core competencies that future talents should possess. In terms of research methods, practical research related to discipline or curriculum development is booming. Many research findings suggest that DT should be widely used and spread throughout lifelong education institutions, as well as thoroughly researched for its significance and educational effect value. Another study of 70 university education experts used the empirical research method to show which DT processes teachers use when developing courses to develop students' abilities appropriate for various grades and majors and achieve on-demand teaching (Hwang et al., 2019). At the same time, 95.7% of experts said they needed DT education. The three points below summarize DT and educational innovation.

To begin, DT gives teachers the ability to grow and design their own lessons. According to William Butler Yeats, "Education is not the filling of a pail, but the lighting of a fire." Students should be helped to prepare for their future lives at school. Wiggins (1993) emphasized the importance of this concept by stating that teachers should assign important tasks or problems that can attract students and are actually related to the real world, and students must use what they have learned to solve problems creatively and effectively. Students' perspectives on these issues are essentially the same as adults' perspectives on social and professional issues. As designers of learning activities, teachers are oriented by students' behavior, pay attention to the interaction between environment, process, and learners, observe design challenges, connect ideas with solutions, and help students reflect and improve their design, according to the constructivist teaching perspective. The DT model has evolved into an effective teaching strategy framework, shifting from solving teaching problems to assisting students in actively discovering problems and seeking opportunities. University of Tampere, in Finland, for example, uses DT to inspire students to innovate in the media industry (Lugmayr, 2011).

Second, DT empowers students to learn. One research report *Rethinking Education*: *Towards a Global Common Good?* released by UNESCO in 2015 states that learning is understood here to be the process of acquiring such knowledge. It is both a process and the result of that process; a means, as well as an end; an individual practice as well as a collective endeavor (UNESCO, 2015). As a learning method of constructivism, design thinking gives full play to individual initiative, pays attention to collective creativity in the process of teamwork, and embraces the digital age. A school in India uses DT to create a three-stage learning model that corresponds to the learners "problem situation stage," allowing them to quickly enter the learning state, learn flexible learning, then team learning, and finally gain "Creative Problem-Solving" thinking ability, cultivate self-management ability, and change the environment.[3] DT advocates "empathize" in order to perceive social problems, and it employs the collision of abstract, divergent, and convergent thinking, logic, and intuition to explore problems and create an environment conducive to learners' independent development.

Third, DT gives "future schools" power. As Julia Gillard said in 2011, development in the future is contingent on competitiveness, innovation, technology, and productivity, all of which are contingent on our education. Since 2006, the Philadelphia School District and Microsoft Corporation have collaborated on the development of the "Future School," attempting to compensate for many shortcomings of traditional schools and aiming for three major innovations: (1) Learning method innovation: there are no books or boundaries in future school classrooms, and there are no unified regulations on students' rest time and learning progress, and research-based learning is encouraged. (2) Learning environment innovation: The future school learning environment must be integrated, multidimensional, and cost-effective. (3) Management mode innovation: the main body of management is the tripartite collaborative management of schools, society, and families, which necessitates the intervention of various experts. According to Thomas, the author of a best-selling book *The World is Flat*, "the skills that students need to succeed in college are different from those that they need to succeed in life and work after college. We will use not only the limited knowledge we learned in college but also the infinite knowledge we have been learning, reshaping, and re-learning in our career for forty or fifty years." This also necessitates that future schools, teachers, and educators make adequate preparations for talent training in accordance with the knowledge and skills required in the future. *The Global Achievement Gap* outlines seven survival skills for the twenty-first century: (1) Critical thinking and problem-solving ability. (2) Cross-border collaboration and leading by example. (3) Adaptability and flexibility. (4) Initiative, initiative, and more initiative. (5) Excellent written and oral communication abilities. (6) Information gathering and analysis skills. (7) Curiosity and creativity. The things he cares about as a future educator must be rich and diverse, and the center of teaching should be shifted to the center of educating people.

In this chapter, after summarizing common models of DT and corresponding tools, we can see the connotation of DT empowering education and teaching in three aspects: (1) DT encourages students to create and solve schemes based on real-world problems. In education and teaching, DT assists students in establishing the relationship between knowledge and skills that can be used to solve real-world problems. It is inextricably linked to specific problem situations and has a clear direction and purpose (Wang & Xin, 2021). (2) DT is presented as a dynamic process that develops through iterative cycles. Teachers did not previously teach students' thinking and skills in an integrated manner, but DT combined practical skills with

[3] http://schoolriverside.com.

abstract theories, allowing students to stand on a holistic view and alternate from a macro perspective to micro implementation. Throughout this process, students' problem-solving abilities, innovative consciousness, and logical thinking abilities were continuously improved. (3) DT is open and creative, and it can be thoroughly assessed. There are no established concepts or knowledge point expectations in the process of assisting teachers with DT, and learners are not restricted by roles, resulting in an open and innovative problem-solving environment. Throughout the process, new ideas, verification, and solutions will emerge to assist learners in thinking and judging. As a result, DT is founded on "people's needs." It follows a specific DT model and DT process and constantly compares, analyzes, and corrects it to form the "best scheme" through teamwork. Every educational innovator and learner who wants to have more creative thinking and problem-solving skills requires such core competencies.

The wise hear in silence and see in darkness. We look forward to people of insight, to jointly promote the development of design education, to gather more researchers who are passionate about design education, to change the evaluation mechanism, to cultivate talents engaged in innovative design, and to build a professional teacher team that is engaged in training innovative talents for a long time to come. To be valuable, any classroom or teaching tool relies on the knowledge of a skilled educator.

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Chapter 5
The Processes and Practice of Using Design Methodology in Education: A Case Study of Edmodo Classroom

Dejian Liu

Abstract This chapter aims to examine the design methodologies employed in developing educational products, with a specific focus on the case study of Edmodo Classroom. **The design methodology employed in this research is Design Methodology in Education (DME), derived from Design Methodology**. DME entails six design processes: needs analysis, user analysis, stakeholder analysis, competitor analysis, scenario analysis, and presentation. These processes aim to highlight the significance of understanding user needs, analyzing social and educational scenarios, considering stakeholder perspectives, and assessing the competitive landscape. DME is based on a design methodology specifically tailored for educational scenarios, serving as a framework as well as the scaffolding for educational product development and aiding educators in understanding and applying it more effectively. The application of DME is illustrated through a case study of Edmodo Classroom. Through adhering to a structured design approach, Edmodo Classroom effectively addresses the challenges faced by teachers, providing an integrated platform that facilitates educational collaboration and instruction. The case study offers a practical demonstration of the application of DME and presents valuable insights for developing optimal educational products.

5.1 The Concept and Framework of Design Methodology in Education (DME)

The product design team at NetDragon Software Holdings Limited has drawn on their extensive experience in developing popular online products to outline a set of design theories tailored for such products—the Design Methodology. The Design Methodology has been consistently improved over the years and has been incorporated into educational projects, competitions, and products, culminating in the

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structure of four fundamental sections: “Needs”, “Feasibility”, “Ideation” and “Prototype”. These four sections have given rise to Design Methodology in Education (DME), which is widely utilized in various fields, particularly in designing smart learning environments, teaching and learning activities, and educational products, contributing to numerous remarkable cases.

DME encompasses four section structures and six design processes. The four sections include Needs, Feasibility, Ideation, and Prototype, while the six design processes comprise needs analysis, user analysis, stakeholder analysis, competitor analysis, scenario analysis, and presentation. These structures and design processes stem from the belief that “everyone is a designer and design is pervasive in every aspect of life”. The methodology is visual, structured, and logical, making it highly adaptable.

Section one, known as “Needs”, involves “Needs Analysis”, “User Analysis”, and “Stakeholder Analysis”.

The primary design process, “Needs Analysis”, is the logical starting point for the educational design methodology (Brindley, 1989; Long, 2005). Design is the intentional conversion of information, knowledge, technology, and creativity into tangible products, works, and services. Therefore, accurately defining specific needs and challenging conventional thinking at the beginning of the design process is crucial. This approach enables the analysis and understanding of requirements from multiple perspectives, dimensions, and levels.

The second design process, “User Analysis”, plays a vital role in the educational design methodology by obtaining precise requirements, including identifying user types, conducting structured analysis, and identifying the essential needs of users. User types can be classified into various categories based on different dimensions, and in this methodology, it specifically refers to the target users, namely, the most significant group of individuals who utilize the product and service.

The third design process, “Stakeholder Analysis”, is an essential aspect of the educational design methodology for comprehensively obtaining potential needs and serves as a crucial reference for assessing the significance and priority of the needs. The analysis consists of four phases: identification of stakeholders, assessment of stakeholder importance, stakeholder analysis, and design inspiration (Brugha & Varvasovszky, 2000).

Section two, known as “Feasibility”, encompasses design processes of “Competitor Analysis” and “Scenario Analysis”.

“Competitor Analysis”, the fourth design process, is a crucial element of DME as it aids in the “Ideation” stage. This involves thoroughly utilizing competitor analysis to explore similar products, utilize comparable products, or identify essentially identical competitors. By Competitor Analysis, we can attain a higher starting point for design, evaluate the solution, and reduce the marketing risks.

“Scenario Analysis”, the fifth design process, is an indispensable aspect of DME. Scenarios represent relative or integrated environments surrounding situations within specific time frames (Agostinho et al., 2005; Bradfield et al., 2015). Understanding the social context in which an individual engages in a particular activity is vital for design practices addressing diverse challenges or requirements. Detailed analyses of audience behavior and activities in specific scenarios can unveil hidden needs or root causes, leading to more targeted, comprehensive, and effective design solutions.

Both the "Needs" and "Feasibility" sections are examined to contribute comprehensively to the outputs of Section Three—the Ideation, such as product design and creative concepts. The ideation phase entails thorough discussion and analysis to foster initial solutions (Brown & Katz, 2009). By promoting divergent thinking through brainstorming, design ideas become contiguously clearer. Creative concepts are analyzed, selected, or merged to develop convergent solutions that harness collective intelligence.

The fourth section "Prototype", includes the sixth design process "presentation", is a critical step in the output of DME, serving as the key link between information, knowledge, technology, and creativity in the design process. Following in-depth analysis and conceptualization, the solution is expressed and presented in various forms such as tables, mind maps, storyboards, and documents. Through "Presentation" stage, the multi-layered nature of artifacts, products, and commodities is revealed, thereby enriching the DME framework.

The DME framework is shaped by flexibly integrating the four key structures and the six design processes (Fig. 5.1). The general design phase forms the initial ideation and presentation through detailed needs analysis, competitor analysis, and scenario analysis. User analysis is integrated into the initial ideation and presentation in the conceptual design phase to generate a function list. Stakeholder analysis will be introduced in the product design phase to study individuals associated with the needs, explore their relevant interests, satisfy those interests, avoid potential conflicts, improve the feasibility of the design solution, and eventually generate a product model. In commodity design phase, after an initial solution has been developed, it will be continually adjusted and optimized through solution review, ultimately resulting in the best solution. This iterative process ensures that design solutions are refined and tailored to meet the specific needs and challenges identified in the early stages of the educational design methodology.

The six design processes are analyzed and can be flexibly paired at different design phases.

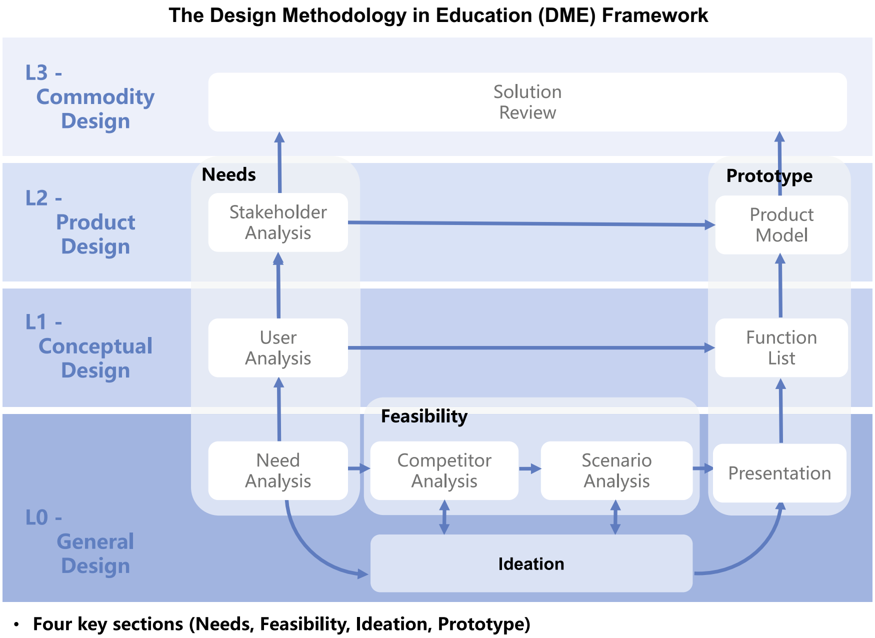

Fig. 5.1 The Design Methodology in Education (DME) framework

5.2 The Design Process of the Design Methodology in Education (DME)

Designing a successful solution necessitates a methodical approach that encompasses numerous vital components. The designing process commences with a thorough analysis of needs, focusing on precisely defining specific needs and identifying requirements. Next comes user analysis, which aims to gain a comprehensive understanding of the characteristics and needs of the target users. Stakeholder analysis examines individuals or organizations that influence the product or service. Competitor analysis establishes a benchmark for functionality and innovation. Scenario analysis delves into user behavior in specific situations to uncover latent requirements. Lastly, presentation involves articulating creative ideas in various formats. Together, these processes establish a comprehensive and robust scaffolding to facilitate the creation of the optimal solution.

Table 5.1 Needs analysis worksheet

<table>
<tr><td>Stakeholders</td><td></td><td>Project Name</td><td></td></tr>
<tr><td>Time Requirement</td><td></td><td>Target User</td><td></td></tr>
<tr><td colspan="2">Original Requirement Description</td><td colspan="2">Design Purpose</td></tr>
<tr><td colspan="2" rowspan="3"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Usage Scenario</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>Keywords</td><td colspan="3"></td></tr>
</table>

5.2.1 Needs

5.2.1.1 Needs Analysis

Needs Analysis is a critical component of the design process, consisting of four stages: *Needs identification, Needs filtering, Needs structuring, and Needs confirmation.* The ultimate goal is the creation of a "Needs Analysis Worksheet". Throughout the needs analysis process, it is essential to facilitate stakeholders in expressing their fundamental and unadulterated thoughts, focusing on identifying needs rather than delving into detailed discussions on potential solutions.

Needs identification is the initial step, involving the identification of stakeholders and the utilization of diverse methods such as user feedback, questionnaire surveys, interviews, and meetings to collect raw requirements.

Needs filtering follows, where valuable and reasonable requirement information is distilled from the collected raw requirements, while overtly unreasonable demands are eliminated.

Needs structuring is a subsequent stage, wherein the filtered raw needs are systematically organized and structured. The resulting information is then recorded in the "Needs Analysis Worksheet" (Table 5.1). This worksheet serves as a valuable tool for clear information presentation, aiding in comprehension, communication, and subsequent review during the design process.

Needs confirmation is the final stage of needs analysis. Upon completion of the "Needs Analysis Worksheet", a comprehensive confirmation is conducted with the stakeholders to ensure mutual understanding and agreement.

5.2.1.2 User Analysis

User Analysis involves a comprehensive examination of the target users or user groups for the design solution. The primary objective of user analysis is to gain a thorough understanding of various user characteristics and attributes, including physiological, psychological, and social aspects, which can provide inspiration for the design process. User Analysis encompasses three stages: *identifying target users,* *analyzing target user attributes, and describing target users*, ultimately resulting in the creation of a “Target User Worksheet”.

The stage of *identifying target users* is pivotal in establishing the overall design direction and serves as a fundamental basis for subsequent design activities. Designers employ various methods such as user surveys, scenario experiments, questionnaires, data analysis, and user modeling to accurately identify the target users.

Analyzing target user attributes involves a detailed examination of the attributes of the identified target users. This analysis encompasses the acquisition of user attributes, description of attribute labels, and derivation of design inspiration. User attributes span a wide range, including general attributes, economic attributes, cultural attributes, community attributes, hardware attributes, software attributes, as well as behavioral habits, and psychological characteristics. After acquiring the attributes, they are interpreted through descriptive labels, and design inspiration is generated using fragmentary and exhaustive approaches. This inspiration can manifest as usage scenarios, potential functionalities, rules, and distinctive features.

Describing target users entails summarizing the characteristics of the identified user group and completing the “Target User Worksheet” (Table 5.2). The description should adhere to principles of readability, concreteness, and distinctiveness, providing a concise and informative overview of the target user group.

Table 5.2 Target user worksheet

Target User			
User Interview Record			
Q: **A:**		**Q:** **A:**	
Attribute Labels		**Attribute Label Description**	**Design Inspiration**
Basic Attributes	**General Attributes**		
	Economic Attributes		
	Cultural Attributes		
	Community Attributes		
	Hardware Attributes		
	Software Attributes		
Characteristics Attributes	**Behavioral Habits Characteristics Attributes**		
	Psychological Characteristics Attributes		

5.2.1.3 Stakeholder Analysis

Stakeholder Analysis focuses on individuals or organizations, referred to as stakeholders, who have an impact on or interest in the use, experience, or outcomes of a product or service. The analysis consists of four stages: *identifying stakeholders, assessing stakeholder's importance, stakeholder analysis, and design inspiration.* The ultimate goal is to create a "Stakeholder Analysis Worksheet" that enables the expansion of positive stakeholder influence while mitigating negative impacts.

Identifying stakeholders involves recognizing common stakeholder types such as users, investors, collaborators, buyers, regulatory bodies, other interested individuals, or organizations, as well as software and hardware entities. Stakeholders are typically identified by considering the product's context and different stages of its life cycle.

Assessing stakeholder's importance entails evaluating the impact stakeholders have on the product's requirements and design. Factors such as their level of concern, power, influence, support attitude, and urgency are considered to prioritize stakeholders accordingly.

Stakeholder analysis involves a thorough examination of stakeholders based on their interests, negative impacts, expectations/requirements, and objectives/motivations. This analysis assists designers in accurately understanding the value and necessity of requirements, thereby deriving design inspiration.

Design inspiration is the extraction and transformation of insights gained from stakeholder analysis into functionalities or new scenarios that stakeholders may require. This provides a foundation for design and can take the form of product usage scenarios, rules, characteristics, and more. Multiple feasible functionalities and scenarios are extracted, resulting in the "Stakeholder Analysis Worksheet" (Table 5.3).

Table 5.3 Stakeholder analysis worksheet

Stakeholder Name	Type	Benefit Analysis	Expectations/Requirements/ Objectives/Motivations	Design Inspiration
Summary				
(Summary of stakeholder needs, values, objectives, motivations, etc.)				

5.2.2 *Feasibility*

5.2.2.1 Competitor Analysis

Competitor Analysis serves the purpose of providing reference points for functions, usability, and key technologies in the design process. By understanding how competitors satisfy the needs of target users, it helps to discover alternative ways to address core requirements. Competitor Analysis involves four stages: *competitor identification, competitor selection, competitor breakdown, and feature integration.* This analysis facilitates self-analysis and the development of feasible methods, enhancing the feasibility, stability, and innovation of the proposed solution.

Competitor identification entails the utilization of various online and offline channels to collect a wide range of competitors accurately and comprehensively, providing material for subsequent selection.

Competitor selection involves categorizing gathered competitors based on identical functions, similar core functions, and the same function in nature. This categorization facilitates the quick extraction of a comprehensive product function list.

Competitor breakdown includes a systematic analysis of competitors. This analysis aims to understand their strengths and weaknesses while identifying functions, interaction designs, and product experiences that can be learned. By examining competitors from different levels, more functions are discovered, contributing to design inspiration.

Feature integration combines the advantages of multiple competitors by integrating their functions. The importance of each feature is indicated through this process, resulting in a preliminary product structure and framework. Ultimately, the "Competitor Analysis Worksheet" (Table 5.4) is created.

Table 5.4 Competitor analysis worksheet

Competitor Classification	**Competitor Name**	**Competitor Introduction**	**Core Function Points and Design Significance**	**Design Inspiration**
Identical Functions				
Similar Core Functions				
Same Function in nature				
Summary				
(Main Competitive Points, Key Design Inspiration)				

Table 5.5 Scenario analysis worksheet

Scenario Listing	Scenario Analysis	Feature Extraction
Summary		
(Design inspiration from Scenario Analysis)		
Note: Typical learning scenario include classroom lectures, self-study, collaborative learning, learning by doing, work-based learning, etc.		

5.2.2.2 Scenario Analysis

Scenario Analysis aims to explore user behaviors and psychology within specific scenarios through meticulous analysis. Its primary objectives include uncovering the essential needs of target users, identifying hidden needs and their underlying reasons, and providing support for targeted design. This process involves three stages: *scenario listing, scenario analysis, and fe*ature *extractio*n, ultimately resulting in the creation of a "Scenario Analysis Worksheet".

During *scenario listing*, comprehensive brainstorming techniques and exhaustive methods are employed to list all elements related to the task. These elements encompass various aspects, such as time, location, individuals, causes, processes, props, and usage conditions. The goal is to identify all possible contexts based on the listed elements.

Scenario analysis entails a detailed examination of user behaviors, emotional experiences, and psychological processes within each identified context. This analysis aims to identify recurring problems, expectations derived from the original requirements, and situations that can fulfill users' higher-level needs, such as respect, self-realization, and self-expression. *Feature extraction* is derived from the analysis of context descriptions. It involves identifying functional requirements, rules, features, or considerations necessary to address the identified needs. These extracted elements are recorded in the "Scenario Analysis Worksheet" (Table 5.5), providing recommendations for subsequent solution development.

5.2.3 Prototype

5.2.3.1 Presentation

Presentation is positioned at the core of the design thinking process and involves presenting creative ideas through various forms such as tables, mind maps, storyboards, and documents. During the overall design phase, the presentation involves

Table 5.6 Function list worksheet

Primary Function	Secondary Function	Function Description

Table 5.7 Product model worksheet

Primary Function	Secondary Function	Function Description	Function Model Diagram
Overall Model Diagram			

Table 5.8 Solution review worksheet

Primary Function	Secondary Function	Function Description	Competitor Assessment
Overall Solution Evaluation			

extracting initial product design directions from needs analysis, competitor analysis, and scenario analysis, which should be integrated throughout the design process. In the case of conceptual, product, and commodity design phases, presentation requires organizing design inspiration obtained from user analysis, stakeholder analysis. It involves considering which functionalities need to be designed, where these functionalities come from, and how they should be designed. As a result, it leads to the creation of a function list (Table 5.6), a product model (Table 5.7), and a solution review (Table 5.8).

5.2.4 Case Study—Edmodo Classroom

The twentieth century witnessed the emergence and growth of the Internet, while the twenty-first century is distinctly characterized by "Internet Plus"—a concept that encapsulates the integration of the Internet and other information technologies into traditional industries. Education, among many sectors, is notably experiencing this evolution.

There's a clear shift toward digitization and informatization in educational resources, with the traditional classroom setup of blackboards and chalk making room for multimedia and interactive teaching methods. This transition is exemplified by the widespread adoption of PowerPoint as a teaching tool, signaling a major change in the way we learn and teach.

Yet, despite the enriching effect of PowerPoint on classroom engagement and student interest, challenges persist. These include content uniformity and the laborious nature of content creation. In response, the industry is keenly exploring how information technology can be utilized more effectively in education. In this landscape, Edmodo Classroom[1] has emerged as a solution seemingly custom-made for these challenges.

Edmodo Classroom is more than just teaching software; it embodies a new paradigm in education that seamlessly integrates internet technology with educational demands. Leveraging big data and cloud computing, it provides a vast and varied repository of teaching resources. This significantly eases the burden of lesson planning for teachers, enhancing both the efficiency and quality of teaching. Additionally, Edmodo Classroom incorporates advanced technologies like VR/AR to create an immersive learning environment, making the learning experience more engaging and dynamic for students.

The development of Edmodo Classroom involved a deliberate design process that aimed to address various needs and achieve specific design objectives. In this section, we will delve into the DME employed in creating Edmodo Classroom, providing a comprehensive understanding of how this educational product was conceptualized and brought to fruition. The examination of Edmodo Classroom's design process will exemplify the practical application of DME in meeting the diverse requirements of educational settings and reaching successful design outcomes.

5.2.5 Needs

5.2.5.1 Needs Analysis

Using PowerPoint as a tool for crafting instructional presentations is common among educators, owing to its user-friendly interface and convenient features. In comparison to traditional teaching methods, PowerPoint empowers teachers to incorporate diverse multimedia elements such as videos, images, animations, and sounds, thereby enhancing the overall quality of classroom instruction. However, many teachers encounter challenges in efficiently producing engaging and high-quality presentations. These difficulties primarily stem from the sourcing and curation of suitable materials and resources during the presentation creation process. Furthermore, the availability of simplified teaching resources and tools is limited. Additionally, collecting and organizing teaching designs and materials can be a time-consuming

[1] https://class.101.com/.

task. The presence of readily available teaching materials would greatly simplify the process of creating presentations. Consequently, teachers express a need for PowerPoint software that not only offers a wide range of presentation resources but also provides unique teaching tools to streamline their lesson preparation.

Edmodo Classroom is precisely the software developed to address the aforementioned challenges and assist teachers in their lesson preparation. It encompasses features such as intelligent resource matching, auxiliary tools, and the capability to control presentations using mobile devices. Moreover, it provides high-quality 3D and VR content resources across various fields, creating immersive and realistic learning environments. For teachers, Edmodo Classroom represents an opportunity to save preparation time while leveraging a wealth of content resources to enhance the effectiveness of their teaching.

Undoubtedly, the user pain points described above serve as crucial sources of original requirements. In the context of Edmodo Classroom, these pain points constitute feedback from users and contribute to the identification of these original requirements. It is important to note that while there exists a close connection between original requirements and user pain points, they are not synonymous. Original requirements refer to the unprocessed needs that users seek in a product or service, whereas pain points signify the aspects of product or service usage that users find inconvenient, dissatisfying, or troublesome.

In the case of Edmodo Classroom, the scarcity of readily available teaching materials and the time-consuming process of creating teaching resources serve as pain points for teachers. The original requirements articulated by users encompass the need for software that offers a comprehensive range of presentation resources, unique teaching tools, and simplifies the process of lesson preparation. By aligning with these user requirements, companies can develop targeted products that effectively address these needs. This plays a pivotal role in how Edmodo Classroom successfully captures user pain points and achieves market success.

To summarize, there is a direct connection between original requirements and user pain points. Pain points can be seen as a subset of original requirements, representing the currently unmet needs. In other words, pain points can be transformed into original requirements. When analyzing original requirements from the perspective of user groups, the focus lies on the needs of the majority of users, while also considering other sources such as user feedback, insights from product-related personnel, market demands, and the company's vision.

Taking user feedback as an example, we can filter and organize these original requirements to create a concise table of original requirements (refer to Appendix A, Table 5.9).

5.2.5.2 User Analysis

To create a product that deeply understands and resonates with users, relying solely on business requirements, logical data, and empirical knowledge is insufficient. It is essential to design the product with the target users in mind and conduct in-depth analysis of their characteristics, needs, and motivations. This process is known as target user attribute analysis.

Target user attribute analysis involves abstracting user profiles based on information such as users' social attributes, lifestyle habits, and consumer behaviors. User profiles are invaluable for many companies. From a strategic perspective, a well-defined user profile can provide market insights, assist in setting phased goals, and guide major decisions. From the product's perspective, user profiles facilitate user segmentation, determine the core audience, and aid in defining the product's positioning and optimizing its features. From a data management standpoint, user profiles help build data assets, extract data value, improve data analysis accuracy, and even enable data transactions to foster data circulation.

Our target user attribute analysis provides an effective method for constructing user profiles. It encompasses dimensions such as basic attributes, economic attributes, cultural attributes, community attributes, software and hardware attributes, as well as behavioral habits and psychological aspects. Through these dimensions, we can develop clear and comprehensive target user profiles.

In essence, target user attribute analysis involves "labeling" users. Taking Edmodo Classroom as an example, we can initiate the analysis by considering the aforementioned dimensions. For instance, we can explore basic information such as gender, education level, and age, as well as delve into interests, hobbies, device preferences, and lifestyle habits. These insights allow us to assign suitable labels to different user characteristics. In the context of the Edmodo Classroom project, the target user group consists of K-12 teachers, typically ranging in age from approximately 23–45 years. They tend to appreciate visual elements with a fresh and elegant cultural style. Due to the nature of their profession, their social circles may be relatively limited, and they may exhibit specific needs related to socializing and collaboration.

Furthermore, it is essential to consider certain often overlooked psychological traits. For instance, many teachers may not possess advanced software proficiency, which can arouse anxiety when encountering new products, especially those with comprehensive functionality. This psychological barrier may lead them to abandon product usage unless they receive external support. Hence, when designing tasks, it is advantageous to adopt a gradual learning approach and provide guidance tailored to beginners. Additionally, teachers inherently compare and compete with one another, aspiring to be at the forefront of their professional community and fearing falling behind. To address this, product design can incorporate elements that display task completion percentages, thereby stimulating teachers' desire to surpass their peers and fostering their engagement. Another effective strategy could involve displaying a message such as "You have surpassed x% of teachers nationwide" upon completing all tasks, instilling a sense of accomplishment and positioning the user for continued engagement.

Through comprehensive analysis, we can identify numerous potential user attribute labels. These labels, in turn, inspire relevant design insights and considerations (refer to Appendix A, Table 5.10).

5.2.5.3 Stakeholder Analysis

When examining the stakeholder "education departments in different regions" in the context of Edmodo Classroom, their role and impact in the project are taken into consideration. It is acknowledged that there may be a potential negative impact on education departments, as the platform may require them to change their existing work methods and invest additional effort to adapt to the digital learning environment. To mitigate disruption to education departments, the designers thoroughly analyze the reasons for the negative impact and employ positive solutions. They ensure that the platform allows for the continued use of locally accumulated educational resources, thereby reducing the costs associated with changing work methods and alleviating the negative impact on education departments. Another stakeholder group in the product, the students, may have concerns related to privacy and data protection within the Edmodo Classroom platform. To minimize the risk of encroaching upon students' privacy, the designers prioritize implementing robust security measures, including encryption and stringent data handling protocols. Additionally, they provide clear and accessible information on how student data is collected, stored, and used, ensuring transparency and building trust.

Furthermore, it is important to differentiate between expectations/requirements and objectives/motivations. In the context of Edmodo Classroom's product design, when analyzing the target users (teachers), their needs during classroom management and instruction are identified. For example, teachers may have requirements such as the ability to quickly distribute assignments, engage students in discussions, and provide timely feedback. However, without analyzing the objectives/motivations behind these requirements, designers might solely focus on features like "assignment distribution" and "discussion forums". By analyzing the objectives/motivations, designers uncover the true purposes behind these requirements, such as "streamlining classroom management" and "enhancing student engagement and learning outcomes". This understanding of teachers' characteristics and attributes, such as their workload and desire for personalized instruction, combined with consideration of their acceptance of digital learning tools, leads to the derivation of more design inspirations. This, in turn, results in features like "simplified assignment management", "interactive discussion features", and integrations with other educational tools. These features cater to the practical needs of teachers and enhance the overall effectiveness of the Edmodo Classroom platform.

By conducting stakeholder analysis and identifying their pain points and desires, designers can generate more design inspiration. Ultimately, a stakeholder analysis worksheet specifically for Edmodo Classroom can be created (refer to Appendix A, Tables 5.11, 5.12, and 5.13).

5.2.6 *Feasibility*

5.2.6.1 Competitor Analysis

Competitor analysis plays a crucial role in identifying similar products and understanding the competitive landscape. One important step in this process is determining keywords that encapsulate the essence of a product and serve as a basis for finding competitors. In the case of Edmodo Classroom, a presentation software for teachers, conducting a competitor analysis can be facilitated by using keywords such as lesson preparation, instructional assistance, teaching tools, educational resources, teaching services, efficient classroom, instructional design, teaching, class, and education. These keywords can be utilized to search for competitors through search engines like Baidu and Google, as well as app stores, professional websites, and industry research reports.

By leveraging these keywords, a comprehensive list of competitors can be compiled and classified into different types, leading to the creation of a competitor analysis worksheet (refer to Appendix A, Table 5.14). This worksheet provides a structured overview of the identified competitors, their strengths and weaknesses, market position, and other relevant information. Analyzing competitors through this process enables a better understanding of the competitive landscape and assists in making informed decisions regarding product positioning, differentiation, and strategy.

5.2.6.2 Scenario Analysis

Scenario analysis is a valuable technique in product design that involves constructing and designing user contexts or situations in which the product is used. Using the Scenario analysis of Edmodo Classroom as an example, consider a teacher using interactive tools who encounters the following scenario: During a class session, the teacher intends to enhance the classroom atmosphere through interactive tools. However, the abundance of available tools leads to a prolonged search, causing anxiety and frustration. This scenario describes a common situation faced by teachers during their instructional activities. By identifying the teacher's psychological state of anxiety while using the product, the subsequent task is to uncover the underlying causes and find solutions.

DME emphasizes listing an adequate number of contextual elements and identifying useful elements that frequently occur across various contexts and possess typical characteristics. In the case of Edmodo Classroom, useful time elements may include before class, lesson preparation, during class, and after class. Useful location elements may include home, office, classroom, and so on.

Using the example of "Edmodo Classroom—Resource Sharing", we can illustrate the process of listing contextual elements, scenario listing, and descriptions within scenario analysis. Edmodo Classroom requires a feature that allows teachers to distribute educational resources to students. Teachers can easily share learning materials such as exercises, Word documents, PDF files, and videos with students through resource packages, enabling convenient access and browsing.

In the case of “Edmodo Classroom—Resource Sharing”, the basic context can be described as follows: Teacher Wang shares pre-prepared English reading materials with students during a class session for independent study. Subsequently, the teacher provides explanations and addresses students’ questions, believing that this teaching approach enhances the effectiveness of the lesson.

To categorize scenarios effectively, fragmentary and exhaustive methods can be employed based on commonly used types, including time, location, people, props, usage conditions, causes, and processes. Examples of such categories include people (teacher, student, parent, staff, male student, female student), location (office, campus, playground, classroom, home, southern region, northern region), time (daytime, noon, evening, late night, holidays, weekends), props (textbooks, computers, blackboards, tablets, cameras), and causes (sparking interest, overcoming boredom, fostering an engaging atmosphere, knowledge sharing, comparison).

By combining these elements, the process of scenario listing and description generates multiple contexts and inspires the development of features (refer to Appendix A, Tables 5.15, 5.16, and 5.17). These contextual elements provide valuable insights into the users’ needs and help in designing a product that effectively addresses their requirements within various usage scenarios.

5.2.7 Prototype

5.2.7.1 Presentation

Creating a function list allows us to identify and organize the different functions or capabilities of a product. It assists in determining the importance of each functionality and guides subsequent stages of product design, such as prototyping (Chen & Huang, 2017). In the case of Edmodo Classroom, we can use the “Eye Protection System” functionality module as an example to present a comprehensive functionality list.

Within the framework of the line-of-sight protection module, the primary function is designated as the “distance warning”. The secondary functionalities encompass “automatic concealment at a reasonable distance” and “suppression of subsequent reminders”. The notion of a reasonable distance entails the automated concealment of the warning pop-up when users adjust their distance to an appropriate range while the pop-up is active. Following the concealment of the pop-up, a prompt is presented, conveying the message, “The distance is now deemed appropriate. Please maintain it”. Subsequent to receiving three reminders within a day, users are afforded the choice to opt for “Do not remind me today”. Through a comprehensive analysis of the target users and competitors, the “automatic concealment at a reasonable distance” functionality has been ascribed the status of an indispensable feature. Drawing upon the scenario analysis, it is strongly recommended to incorporate the "suppression of subsequent reminders" capability.

5.3 Summary

The case of Edmodo Classroom demonstrates that DME is fundamentally based on analyzing primitive needs, identifying core problems, analyzing the core characteristics and attributes of target users, conducting competitor analysis to leverage existing products or features, considering influential stakeholders in product design, performing scenario analysis to identify user pain points and pleasure points, and utilizing functionality listing to identify and prioritize the different capabilities of the product. This systematic process enables the selection of the most appropriate solution, defining the core value of the product.

In essence, DME offers a systematic problem-solving approach, serving as a supportive scaffolding for the design process of educational products. DME has the potential to be applied to many industries, provided that individuals are open to adopting and expanding upon them.

Appendix A

Table 5.9 Needs analysis worksheet—Edmodo classroom

<table>
<tr><td>Stakeholders</td><td>Edmodo Classroom Project Manager</td><td>Project Name</td><td>Edmodo Classroom</td></tr>
<tr><td>Time Requirement</td><td>/</td><td>Target User</td><td>K-12 Teachers</td></tr>
<tr><td colspan="2">Original Requirement Description</td><td colspan="2">Design Purpose</td></tr>
<tr><td colspan="2" rowspan="3">During the process of creating presentations, it is challenging for teachers to find readily available and simple teaching resources and instructional tools. Teachers invest significant effort in searching for these materials. They hope to have a PowerPoint software that not only provides abundant presentation resources but also offers unique teaching tools to simplify lesson preparation and instruction</td><td colspan="2">Enabling teachers to effortlessly prepare and deliver lessons, our product becomes an instant favorite</td></tr>
<tr><td colspan="2">Usage Scenario</td></tr>
<tr><td colspan="2">Ms. A, a K-12 teacher, uses Edmodo Classroom to prepare and deliver lessons. With the convenience and efficiency of finding teaching resources during lesson preparation and the flexibility to use various classroom tools during instruction, she has fallen in love with this product</td></tr>
<tr><td>Keywords</td><td colspan="3">Edmodo Classroom, educational resource distribution platform, smart classroom, educational software</td></tr>
</table>

Table 5.10 Target user worksheet—Edmodo classroom

Product name	Edmodo classroom		
Target user	K-12 teachers		
Target User Description	The target users are teachers in the K-12 education system, ranging in age from 23 to 45 years old. They hold a minimum of a bachelor's degree and rely on PowerPoint for delivering their lessons. While they have a moderate level of proficiency in both software and hardware, their primary focus is on providing responsible and effective instruction to their students. These teachers value opportunities for collaboration and yearn for recognition and respect from their colleagues		
Attribute Class	Attribute Labels	Attribute Label Description	Design Inspiration
Characteristic Attributes	Responsibility	Teachers are responsible for students' academic performance and discipline	Provide tools for better student supervision and discipline
	Time Management	Teachers have to schedule their work, including lesson preparation, grading, and class timing	Assist teachers in time management and progress monitoring
Cultural Attributes	Intellectual Capacity	Within the normal range	Require no special design considerations
	Cultural Background (Students, White-Collar, Blue-Collar, Migrant Workers, etc.)	Education profession	Align with the cultural preferences and atmosphere of the teaching community
Community Attributes	Socializing Needs	(High) Teachers have a limited social circle and few social opportunities, longing to connect with more people	Design corresponding communication communities or forums
	Sense of Belonging Needs	(High) Teachers have a strong sense of belonging to their school and local community	Design regional and school-based teacher communities, as well as a centralized resource library
Hardware Attributes	Device Ownership	Electronic whiteboard, projector, PC, smartphone	Consider different combinations of terminal devices for lesson preparation and teaching scenarios
	Network Condition	Currently, schools generally have a well-established network infrastructure	Consider the connection methods between teachers and students

(continued)

Table 5.10 (continued)

Software Attributes	Network Familiarity	(Low) Most teachers have only basic knowledge of network usage and are unable to troubleshoot network issues	Consider ways to handle network abnormalities and provide troubleshooting guidance
	Software Familiarity	(Moderate) Teachers have more experience with using PowerPoint for lesson preparation but have limited experience with other software	Avoid changing the way PowerPoint is used and refrain from overly advanced operations in the software design
Basic Attributes	Age	23–45 Years old	Consider catering to the needs of teachers across different age groups
	Education Level	Bachelor’s degree or above	Consider incorporating more advanced functionalities and design considerations

Table 5.11 Stakeholder analysis worksheet—Edmodo classroom—buyers

Stakeholder classification	Stakeholder name	Roles in the project	Importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/ motivation	Functionality/ scenarios
Buyers	K-12 schools (school leaders)	Client	Medium	Responding to the call for information technology education from the higher education bureau, promoting educational reforms, and achieving political achievements (reputation and financial gains) Becoming a pilot school or a star school through information technology educational reforms, enhancing personal and school reputation and status (reputation)	–	Product aimed at enhancing the reputation, prestige, and honor of the school and the principal	Increasing visibility/fame	Collaborate with Beijing Normal University to establish awards for the school Assist in promoting the school and showcasing its excellence
						The product can directly improve academic performance in entrance examinations	Improving performance	Provide a vast question bank and test papers Support "printing" of test papers to help students adapt to paper-based exams

(continued)

Table 5.11 (continued)

Stakeholder classification	Stakeholder name	Roles in the project	Importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/ motivation	Functionality/ scenarios
	Local Educational Departments	Client	Medium	Responding to the call of national leaders to comprehensively promote educational modernization through education informationization, by advancing educational informationization reforms, completing the tasks of "three networks and two platforms" arranged by higher-level departments and the national Ministry of Education, and achieving outstanding political achievements (official recognition and financial gains)	Changed the original work mode, requiring more effort to adapt to educational reforms	Obtaining data to report work achievements to higher-level supervisory departments	Reporting to superiors	Use the achievements report of Edmodo (improvement in exam scores by a certain percentage, increase in parental satisfaction by a certain percentage, increase in student satisfaction by a certain percentage)

(continued)

Table 5.11 (continued)

Stakeholder classification	Stakeholder name	Roles in the project	Importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/ motivation	Functionality/ scenarios
						Desiring a product with outstanding features that can attract industry attention, enhance the region's reputation, and even develop the education industry as a distinctive industry for the local area	Department's reputation	Provide 3D and VR teaching implementation solutions
	K-12 Teachers	Client	Medium	Paying allows access to premium teaching resources (VR, 3D) and exclusive materials from renowned schools (exemplary exam papers), providing unique resources and good value for money Paying enhances the user experience	–	Good quality at an affordable price, low prices but abundant resources and powerful features	Getting the most out of their money by spending the least	Reasonable pricing
						Paid resources are unique and offer great value for money	Pursuing cost-effectiveness	Exclusive resources

(continued)

Table 5.11 (continued)

Stakeholder classification	Stakeholder name	Roles in the project	Importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/ motivation	Functionality/ scenarios
	Training Institutions	Client	Medium	Increasing training fees in a reasonable manner through the use of smart classroom products, resulting in profits Generating additional income streams through the products Gaining more reputation and student enrollment by distinguishing oneself from other institutions and showcasing superior teaching conditions	Increased funding is crucial to adapting to evolving educational reforms and changing teaching methodologies in response to societal and market developments	The product can help showcase teaching achievements and attract more students	Earning money and gaining reputation	It can have a dedicated page to showcase the teaching achievements of the institution
						The purchased product has a certain reputation and can attract students	Obtaining benefits	The product is authoritative and has a good reputation
						High information security ensures that the institution's teaching and research resources are not leaked	Maintaining confidentiality of core materials	Ensuring the information security of the institution's internal resource library

Table 5.12 Stakeholder analysis worksheet—Edmodo classroom—partners

Stakeholder classification	Stakeholder name	Roles in the project	Importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/ motivation	Functionality/ scenarios
Partners	Education Resource Content Production Company	Resource Partner	Medium	Generate revenue through the sale of resources Gain more users or customers through the dissemination of NetDragon Increase company's influence and reputation by leveraging the popularity of NetDragon	Allocate a certain budget for promoting the company's resources	Having a good and fair revenue-sharing mechanism for convenient financial settlement	Making profits through revenue sharing	Attractive revenue sharing model
						Resources used should indicate copyright or source information	Protecting copyright	Adding logos, watermarks, or other identifying marks to resources
	Renowned experts/ teachers in education	Partner	Medium	By promoting and packaging resources or individuals, their value can be enhanced. (Money) (Reputation)	–	Can demonstrate their abilities and viewpoints through the product	Increase visibility	Live streaming, recorded lectures
						Attribution of their personal achievements used should be indicated to enhance their personal brand value	Protect copyright	Display the creator Recommend resources from renowned teachers

(continued)

Table 5.12 (continued)

Stakeholder classification	Stakeholder name	Roles in the project	Importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/ motivation	Functionality/ scenarios
	Educational hardware manufacturing company (Hisense)	Hardware Partner	Low	Obtain a large number of education hardware equipment orders from NetDragon. (Money) Produce devices with excellent performance and receive positive feedback from users. (Reputation) Drive hardware sales and increase sales volume. (Money)	–	Addressing the shortcomings of the software product to make it more comprehensive	Improving the product	–
						Perfect integration of software and hardware products, pre-installed software can effectively highlight the outstanding performance of the device	Attracting more users	The product seamlessly integrates with hardware devices, providing excellent user experience and presentation

(continued)

Table 5.12 (continued)

Stakeholder classification	Stakeholder name	Roles in the project	Importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/ motivation	Functionality/ scenarios
	Publishing company for educational teaching materials	Resource Partner	Medium	Generate revenue through the sale of electronic textbooks. (Money) Increase the reputation and influence of the publishing house by promoting its educational materials. (Reputation)	–	Resources used should indicate copyright or source	Protect copyright	Adding logos, watermarks, and other marks to resources
						The product having a large user base can help increase the visibility of teaching materials	Increase visibility	–

(continued)

Table 5.12 (continued)

Stakeholder classification	Stakeholder name	Roles in the project	Importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/ motivation	Functionality/ scenarios
	Channel distributor	Product Promotion Partner	Low	Generate revenue through advertisements or charging promotion fees. (Money) Increase the influence and reputation of the business by successfully promoting more quality products and attract more orders. (Money and reputation)	–	The product has selling points and highlights, attracting more users to pay attention to this channel	–	–
						Expect to have readily available promotional and advertising materials	Convenient	The company provides unified promotional and advertising materials
	Educational Research Institution	Partner	Low	Gain product support to validate the feasibility of their teaching theories (improve cost-effectiveness) Conveniently obtain teaching data to enhance their teaching methods and content (improve cost-effectiveness)	–	Provide abundant teaching-related materials and data	Offer foundational resource support	Collect data on the usage of resources Provide behavioral data for pre-teaching instructional scenarios
						Able to assist in conducting relevant teaching research activities	Provide technical support	Conduct specialized statistics

Table 5.13 Stakeholder analysis worksheet—Edmodo classroom—users

Stakeholder classification	Stakeholder name	Roles in the project	importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/motivation	Functionality/ scenarios
User	K-12 teachers	Main user, target user	High	[Lesson Preparation] Easier access to teaching resources, saving lesson preparation time. (Cost-effectiveness) [Lesson Preparation] High-quality teaching resources improve efficiency and make lesson preparation easier and more effective. (Cost-effectiveness) [Lesson Preparation] Enhance teaching skills by learning excellent and innovative teaching methods. (Cost-effectiveness)	–	[Lesson Preparation] Learn from renowned teachers and access their teaching materials for learning and reference	Self-improvement	Recommendations for courseware and resources from prestigious schools and renowned teachers
						[Teaching] Enable teachers to deliver lectures and explain concepts and exercises more easily	Reducing workload	Exercises with explanations and answers Teachers can quickly distribute and collect exercises during class
						It can help excellent students delve deeper into a particular subject and participate in various competitions	Gaining reputation	Providing various competition questions and materials

(continued)

Table 5.13 (continued)

Stakeholder classification	Stakeholder name	Roles in the project	importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/motivation	Functionality/ scenarios
	K-12 students	Main user	Medium	Abundant teaching resources help students gain a visual understanding of knowledge, making it easier to comprehend lessons, improve learning efficiency, and achieve better grades. (Cost-effectiveness) Using the product, student engagement in class increases, creating an active classroom atmosphere and reducing distractions, thereby enhancing learning efficiency. (Cost-effectiveness)	Distract students, making it difficult to concentrate	Improve their exam scores	Complete learning tasks	Rich variety of practice questions, answer explanations, and real exam papers
						Diverse teaching formats with various interactive and interesting activities	Engaging classroom experience	Multiple interactive features in the classroom Provide gamified exercises

(continued)

Table 5.13 (continued)

Stakeholder classification	Stakeholder name	Roles in the project	importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/motivation	Functionality/ scenarios
						Being able to witness fresh and novel things in the classroom, broadening one's horizons, and learning knowledge beyond textbooks	Expanding horizons	Provide cutting-edge technologies such as 3D, VR, etc

(continued)

Table 5.13 (continued)

Stakeholder classification	Stakeholder name	Roles in the project	importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/motivation	Functionality/ scenarios
	K-12 school (school leaders)	Common user	Medium	Responding to the call for information technology in education from the higher education authority, promoting educational reform, and achieving political achievements. (Official) (Financial)	–	Expect to comply with the policy of "three connections and two platforms" and promote the information construction of school	Work performance	The product complies with the policy of "three connections and two platforms”
						Help school leaders report their work to the supervising education department	Reporting achievements to leaders	Automatically generate comprehensive reports Reports can be customized with charts and content

(continued)

Table 5.13 (continued)

Stakeholder classification	Stakeholder name	Roles in the project	importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/motivation	Functionality/ scenarios
	Training institution teachers	Potential user	Medium	Utilize the school's internal database for convenient sharing of resources (cost-effectiveness) Access learning materials to enhance teaching skills (e.g., making lectures as interesting as comedic performances) (self-improvement)	–	Earn money and gain reputation through the Edmodo Classroom platform	Earn money and gain reputation	Promote themselves (personal profile)
						Incorporate personalization into the course content to build their own teaching brand	Develop a personal brand to attract more students to enroll in their courses	Customize teaching materials to make them more personalized

(continued)

Table 5.13 (continued)

Stakeholder classification	Stakeholder name	Roles in the project	importance	Interests in the project	Negative impacts	Stakeholder expectations/ demands for the product	Purpose/motivation	Functionality/ scenarios
	Local Educational Departments	User	Medium	Responding to the call of national leaders to "promote education modernization comprehensively through educational informatization", by advancing the reform of educational informatization, fulfilling the tasks of "three connections and two platforms" arranged by higher-level departments and the Ministry of Education, and achieving outstanding political achievements. (Official) (Money)	Changed the original working style and requires investing more effort to adapt to educational reforms	Collect and organize the data that needs to be reported to the leaders during each reporting period	Track supervision	Collect classroom data, teacher usage frequency, classroom feedback effectiveness, peripheral device usage Number of users in the jurisdiction, activity level, frequency of use, etc
						Respond quickly to proposed feature optimization requirements	Ensure efficiency	Provide a fast-response customer service mechanism

Table 5.14 Competitor analysis worksheet—Edmodo classroom

Competitor classification	Category explanation	Competitor name	Competitor description	Reason for selection	Design reference	
The functions are completely identical	It covers the basic requirements and provides a combination of "lesson preparation resources + teaching tools"	PPTclass (PC)	PPTclass is an educational cloud platform that enhances PowerPoint presentations with interactive teaching features. It integrates educational resource libraries and management systems to create a comprehensive solution for schools and regional education systems	Key Features: Easy and user-friendly student connection: Students can simply scan the QR code on the whiteboard using their mobile phones to connect Additional features compared to Edmodo: Class scheduling and management module, quiz and exam module, and synchronous broadcasting functionality	Functionality and tools for lesson preparation and delivery Loaded as plugins on PowerPoint slides Exercise question bank and quiz papers Cloud-based lesson schedule for post-class activities	Other similar competitors include: Youxuepa, Mingbo Youke

(continued)

Table 5.14 (continued)

Competitor classification	Category explanation	Competitor name	Competitor description	Reason for selection	Design reference	
The core functions are similar	The functional modules that meet the original requirements	2013office PPT (PC)	Microsoft Office PowerPoint 2003 is a version of PowerPoint developed by Microsoft. PowerPoint is an essential component of the Microsoft Office productivity suite, which also includes Excel, Word, and other applications	Key Features: Part of the Microsoft Office suite, it offers a wide range of functionalities and powerful performance The user interface is intuitive and user-friendly, making it suitable for both professionals and casual users	Editing resources Beautifying presentations Preview/playback	–
The functions in nature remain the same	In the current traditional education system, physical resources and services are available to assist teachers in lesson preparation and teaching	Multimedia Classroom	A multimedia classroom is the infrastructure for multimedia teaching and is responsible for daily multimedia teaching tasks for teachers and students. It consists of various modern teaching devices such as multimedia computers, projectors, and audio equipment	Key features: Multimedia classrooms enhance two-way communication between teachers and students, promoting personalized learning Multimedia classrooms facilitate student monitoring of the teaching situation	The guidelines for classroom usage	–

Table 5.15 Scenario analysis worksheet—listing contextual elements (Edmodo Classroom—Resource Sharing)

Listing Contextual Elements	
Primary elements	Secondary elements
Person	Elementary School Teacher
	Elementary School Student
	Student Who Loves Learning
	Parent
Time	Before Class
	When Assigning Homework
Location	At Home
	In the Classroom
	Outdoors
Cause	Wanting students to review and preview relevant knowledge during holidays
	To facilitate students in distinguishing different assignments
	Assigning holiday homework to students all at once
Actions	Assigned holiday homework to students
	Made some adjustments to the homework students hurriedly completed the assignments before the start of the new semester
	Previewed and viewed the list of homework contents
Props	Tablet
	Computer
	Textbook
Conditions of Use	With Internet/Without Internet

Table 5.16 Scenario analysis worksheet—listing scene titles (Edmodo classroom—resource sharing)

Listing scene titles		
Number	Scenario titles	
1	[K-12 Teacher] A [Expects students to understand some background knowledge of the lesson] [Searches for relevant materials from various sources, prints them out, and distributes them to students]	Teacher's side
2	[K-12 Teacher] A [Before class, print out some paper materials for students to review]	
3	[K-12 Student] B [Receives the materials sent by the teacher] [Automatically displays on the screen after receiving]	Student's side
4	[K-12 Student] B [Wants to review the content sent by the teacher after class] [Checks "My Resource Library"]	
5	…	

Table 5.17 Scenario analysis worksheet—scenario description and function refinement (Edmodo Classroom—Resource Sharing)

Scenario description			
Number	Scenario description	Function refinement	
1	K-12 Teacher A expected students to understand some relevant background knowledge for this lesson to facilitate their understanding of the key points Before class, he collected related materials from other teachers and downloaded some himself, then printed them out and distributed them to students. He finds printing to be troublesome [Pain Point]	Multiple paths for distributing resources to students (add from school library, add from local resources, add from cloud storage, display the result of adding)	Teacher's side
2	During class, he checked the students' pre-learning results and found that the printed materials are quite dull. K-12 Teacher A printed some paper materials for students to preview before class, but the effectiveness of the pre-learning is not satisfactory. He needs to explain more carefully [Pain Point]	Support for adding multiple file formats (images/audio/videos/PDF/PPT/Office files/txt, etc.), feedback on the result of adding (successful adding prompt, failed adding prompt with reasons and guidance for the next step)	
3	K-12 Student B received the materials sent by the teacher The materials were automatically displayed on the screen, so the student knew whether the resources had been successfully received and where to find the received materials [with satisfaction]	Receiving resources (automatic receiving and storage, displaying the progress of receiving), feedback on receiving results (successful receiving prompt with guidance to view, failed receiving prompt, reattempt receiving)	Student's side
4	K-12 Student B felt that he did not understand the content of the materials sent by the teacher very well during class He wanted to review the materials after class, so he opened "My Resource Library" to find the needed materials for learning, finally fully understanding the key points [with satisfaction]	Viewing "My Resource Library" (displaying a list of resources and showing basic information such as thumbnail, name, format, uploader, upload time, etc.)	
5	…	…	

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Part III
Typical Scenarios and Approaches of Design in Education

Chapter 6
Trust the Teachers: A Collaborative Approach to Learning Design Solutions

Diana Laurillard

Abstract Crucial to any design is its intention, although the world will be the judge of its value. We try to make intention and outcome align, and in the context of learning design its value to the world will be some important advance in contributing to solving one of the many challenges to improving learning and teaching. This chapter focuses on the challenge of how to optimize the potential of digital learning technologies in education and offers collaborative learning design as an effective solution. This challenge is critical because digital technologies have huge potential to transform the effectiveness of education and its inequalities on the large scale. They also have the potential to exacerbate its problems and destroy its successes. Educators must be supremely vigilant to avoid the worst, and diligent to achieve the best. The chapter explains why educators should focus on collaborative learning design and clarifies its theoretical basis. It describes the evidence from experiments that evaluated teachers' experience of a 'co-designed massive open online collaboration' and demonstrated a viable solution for professional development that can scale up teachers' good local learning design solutions to improve the reach and effectiveness of student learning across the world.

6.1 Introduction

There are good reasons for turning our focus to teachers in this chapter. They are by far the most numerous of the education professionals. Across the world, in all sectors there are some 85 million.[1] They are qualified professionals dedicated to improving their students' lives through education, working closely with them every day, developing their knowledge and understanding of how to help each student achieve their learning potential. And yet they are rarely thought of in terms of their importance for the future success of education, even in a world that puts a high

[1] https://www.worldbank.org/en/topic/teachers.

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value on human capital. Instead, they are embedded in a command structure by policymakers, and ignored by the world of high tech.

The aim of this chapter is to claim the right of this extraordinary mass of invaluable people to be at the forefront of innovation in learning design solutions.

We cannot ignore the role of digital technology, of course, because the years of the 2020 pandemic demonstrated to education leaders and thinkers everywhere that online learning was not only an indispensable asset to education, but also had many positive advantages to bring to teaching and learning in general.

The vision for digital learning technology is simply expressed: for every learner to achieve their learning potential. In the physical world we have failed in this on a massive scale, considering the 244 m children with no schooling,[2] or the 41% who fail to achieve the expected standard in reading, writing, and maths after 6 years at school, even in relatively advanced countries such as England.[3] There is no promise that the use of digital technology will succeed where tradition has failed, because it is so dependent on the human organizational systems working well. But digital technology has two significant advantages over the in-person physical world: the capability to adapt to the individual's needs, and the current capacity to reach 65% of the world's population in almost every corner of the planet.[4] With the highly challenging ambition of universal education and lifelong learning,[5] we must think in terms of innovative solutions for the individual, on the very large scale.

The chapter begins with an overview of the progress of work on teacher professional development (TPD) since the introduction of digital technology into education in all sectors, from primary to tertiary. There has been a gradual recognition that we must move on from transmission models of education and enable more active and agentic engagement from teachers, made easier by greater use of the internet. But for teachers, the role of technology is only judged in terms of the benefit it accrues for the learner. Teachers need to challenge it at every step, not being distracted by what it offers, but remaining focused on what *we want it to offer*.

This is why I first developed the Conversational Framework, when digital technologies began to change teaching and learning in the 1990s. The point was to focus attention on 'what it takes to learn', basing the framework on the previous century's work on how students learn. The chapter summarizes this argument and the way it further developed into the research on developing an online design tool for teachers: the Learning Designer. Throughout this research the aim was to focus on individuals' learning needs and how the teacher could design the teaching–learning process in ways that would optimize their learning outcomes.

Over the two decades since the origin of the Conversational Framework digital technologies have developed in unimaginably different and useful forms for improving education. And the edtech industry has grown exponentially with these new opportunities. The industry has never engaged closely with teachers, however.

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[2] https://world-education-blog.org/2022/09/01/.

[3] https://explore-education-statistics.service.gov.uk/find-statistics/key-stage-2-attainment.

[4] https://www.statista.com.

[5] https://www.undp.org/sustainable-development-goals.

They can hardly be expected to develop new educational technology solutions given their workloads, of course, which then justifies their exclusion from the whole design process. So the next phase of the chapter builds the argument for engaging with the vast global community of teachers themselves, spreading the innovation load through a collaborative approach to design. Collaboration does not happen easily, in any context, so this section brings this issue to the surface with the idea of a ‘theory of change’ for education. It is common practice in the international charity sector, less so in research on educational change, but vital, if collaboration is to be productive.

Most importantly, given the scale of the challenges we face, we must take collaboration beyond the local level to the sharing and building of new pedagogic knowledge on the large scale. How can the teaching community emulate the traditions of knowledge building in science and scholarship?

The work being described in the chapter has been developing over the past 12 years or so, and the evidence base for the feasibility of this overall approach is recounted in the two sections that follow. Does it work? Yes, it can, but it is still in its early stages as work in progress.

The penultimate section discusses these ideas in relation to the main questions posed in this book, about the nature of the design thinking approach applied to education challenges to produce effective design. AI’s large language models of human interactions have implications for the field of learning design, and we must be clear about how they might be used, for good or ill.

Finally, the conclusion returns to the imperative in the title: trust the teachers. A volte-face on the policy and practice that excludes teachers from contributing to the direction of future change in education will see ‘teacher focus’ as a viable solution. That is the argument this chapter sets out to make, summarized in Fig. 6.1.

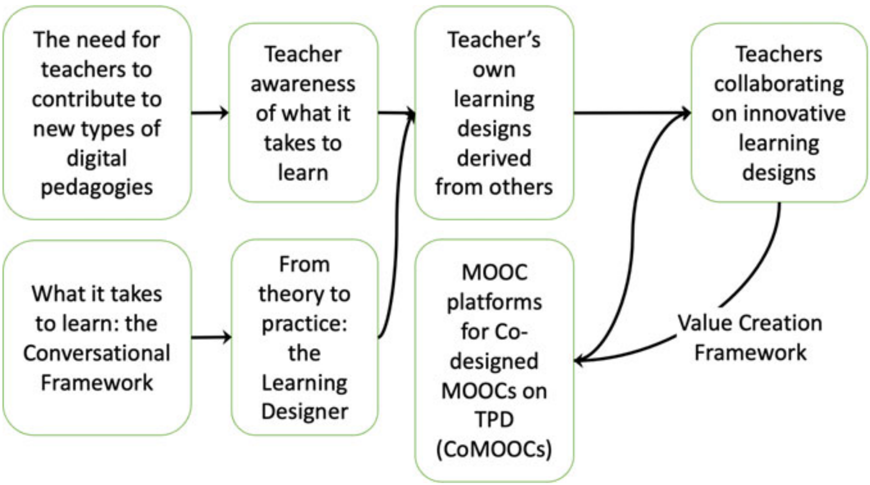

Fig. 6.1 Relationships between the main points of the chapter

6.2 Teacher Professional Development as Collaborative Knowledge Building

Teacher professional development over the first two decades of the twenty-first century has increasingly been seen through a socio-constructivist lens that recognizes the contributions teachers can make themselves, and so shifts the focus from what can be done for teachers to what teachers can do for themselves (Makri et al., 2014; Najafi & Clarke, 2008; Schnellert et al., 2008; Van Driel & Berry, 2012). Najafi and Clarke summarize the point:

> teachers' learning is facilitated and sustained in communities that are collaborative endeavors, acknowledge and value participants with different levels of expertise, and focus on practice-related issues (Najafi & Clarke, 2008, p. 244).

Good, but there is no sense of community knowledge building here. To go beyond local endeavors to the global teaching community, Hiebert and Morris proposed an approach to improving teachers' methods of teaching by creating and sharing artifacts or instructional products (Hiebert & Morris, 2012; Morris & Hiebert, 2011). Such an approach enables understanding to be accumulated over time. Teachers and researchers create materials, try them out, and 'feed the information from the trials back into the products' (Hiebert & Morris, 2012, p. 94). Good, but again there is no emphasis on how we sustain access to that improving body of knowledge.

This iterative process of collaborative sharing of scholarship-informed practitioner knowledge could be the key to reconfiguring teaching as a design science, because it addresses the challenge of teacher-led inquiry (Laurillard, 2012). It helps teachers build their knowledge of teaching by encouraging them to engage in the production and continual improvement of ideas of value to the community (Hong, et al., 2009). Teachers work in 'design mode' (Hong et al., 2009) with a collective goal of innovation and knowledge advancement (Scardamalia & Bereiter, 2010).

Teachers are not so much scientists—who try to understand how the world works. They are more like engineers—who try to make the world a better place. Like engineers, they use science, where it improves what they do. And like engineers, they use feedback, redesigning their teaching in the light of what happens in practice. Teacher collaborative inquiry has been advocated as policy for the profession in the US (USDoE, 2014). 'Design scientists'—the term suits what teachers actually do, except that unlike scientists and engineers they have no established professional tools or mechanisms for harnessing their knowledge, capacity, and engagement in making the new knowledge available to all.

A review of 99 studies of online teacher communities of practice analyzed the main characteristics and practices of these communities and networks (Macia & García, 2016), but found there was rather little research on teachers' online collaboration in the context of professional development. A further review of evidence-based knowledge for teachers argues for going beyond the chimera of discovering and demonstrating 'what works' to implementing policies that include collaborative and research-based designs for TPD reflecting 'how knowledge is acquired and utilised by teachers' (La Velle & Flores, 2018).

Yet, for so many of these approaches, the focus is only on teachers' own local knowledge. There is no expectation that they should see their work as 'part of the civilization-wide effort to advance knowledge frontiers' (Scardamalia & Bereiter, 2006). Why not? If researchers do not listen to that return process of reporting back on the utilization of research findings, the teacher's voice is essentially lost because their focus is confined to informal reflection, or solutions to inform practice within their own classroom context. Instead, teachers could be supported to make broader contributions to educational knowledge (Peel, 2020; Richardson et al., 2018), or become part of a community in the sense of developing 'a shared identity around a topic or set of challenges' (Wenger et al., 2011).

It is striking that in all these studies of teacher engagement with research and community-based learning, there is no proposal that teachers could go beyond their own practice to build a global community for exchanging new ideas and developing new forms of practice. However, for teacher innovation to develop the 'adaptive expertise' needed to cope with rapid change (Schwartz et al., 2005) we need an approach that would encourage teachers to experiment and develop pedagogic knowledge themselves as a community effort.

Such an approach is critical now. The rapid development of digital technologies that could have a positive impact on education means that teachers must be able to play a contributing and critical role to ensure that the impacts are indeed positive. The next section proposes a framework to guide the development of new types of pedagogy, whether wholly online, blended, or entirely in-person, so that we learn how to optimize digitech for every student's learning outcomes. After that, the plan is to exploit the large-scale features of technology-based collaboration.

6.3 Learning Design: What It Takes to Learn

We serve individual students' needs best when we place them as our goal in design thinking. This was the aim of the Conversational Framework for teaching and learning, introduced in 1993, and later updated (Laurillard, 2002, 2012). At that stage, teachers and education researchers were beginning to experiment with digital technologies for learning, intrigued by their potential, even though rather few were developed explicitly for education. It was clearly important to avoid the technology-driven approach, which simply accepted each invention and sought a place for it in educational practice. Instead, teachers needed a more critical approach to technology, one that began by defining what it takes to learn and therefore what kind of technology would be beneficial for student learning.

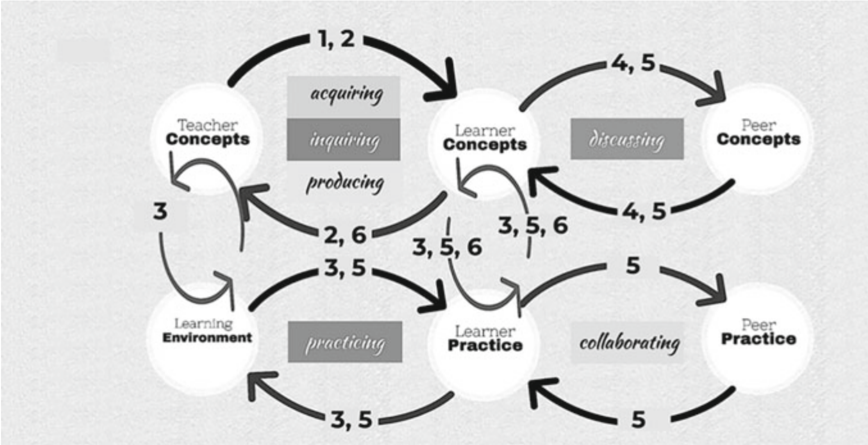

Fig. 6.2 The conversational framework for the teaching–learning process in action (with numbered cycles as below)[6]

6.3.1 Development of the Conversational Framework

The Conversational Framework was developed as a distillation of the main findings of the previous century or so of educational research that was simple enough to guide teachers in planning their students' learning activities in relation to a given intended learning outcome. The research derived from many decades of digital-free learning and teaching but was nonetheless a fundamental representation of our best understanding of what it takes to learn in the context of formal education. The learner's developing capabilities respond to their experiences of the teaching–learning process, whatever form it takes. The question is, how do we design those experiences to help each learner achieve their own learning potential? The goal of an evidence-based framework is to challenge that design thinking whether it is conventional or digital, or a mix of the two.

The framework places the learner at the center of the teaching–learning process, interacting with the teacher (or some representation of their knowledge and guidance, such as a book), and with their peers, the other students on their course (see Fig. 6.2). The upper level represents the teachers' concepts, the learner's developing concepts and the other learners' developing concepts. The learner in the middle represents all learners. The lower level represents the use of the concepts in practice: the 'learning environment' embodies the teacher's idea of how all the learners engage with practice, and it also represents the learner's and their peers' developing practices.

Between these six nodes there are several cycles of interaction between teacher, learner, other learners, and the subject learning environment, each influencing the

[6] *Source* Kennedy & Laurillard (2023).

other. A simple interpretation of the process is to recognize that there are five distinct types of interaction here:

1. Acquiring: the learner's developing concepts affect their practice, which in turn affects their concepts
2. Inquiring: the teacher presents their concepts, and the learner asks, and answers questions, makes comments, and presents their ideas to the teacher, who gives them feedback
3. Practicing: the teacher creates the learning environment to engage learners in the practice and use of the concept, and each learner acts to achieve the goals of the learning environment and uses feedback and reflection on their concept to improve their practice
4. Discussing: each learner discusses, negotiates ideas, asks and answers questions with other learners
5. Producing: each learner reflects on how their concepts and practice have developed and represents this for the teacher to evaluate.

For each one the learner is experiencing that interaction in a fundamentally different way—either by their concepts or practices reacting to the external influence (black arrows), or by internally generating a representation of their concept or practice (red arrows) to influence the other in some way, or both, in sequence. It is then possible to combine these distinct learning types in sequence as a complex teaching–learning activity. However, one type of learning, collaborative learning, is such a significant and frequent combination that it deserves its own distinctive definition as the remaining learning type, usually prior to producing:

6. Collaborating: learners practice, discuss, and exchange or share their practice, to produce a joint output.

The six learning types are similar to the Open University's seven categories of learning activities (Conole, 2010), which were derived from collaborative workshops among the academics. Table 6.1 shows how they relate to each other.

The value of such a framework is that it encapsulates the different roles that teachers and learners need to play for the teaching–learning process to work, and therefore challenges each type of educational technology to meet those demands, not simply offer what the designer thought might be useful. Teachers were excited by the advent of successive edtech innovations such as PowerPoint, compact discs, digital videos, animations, podcasts, etc. as they became available, but the Conversational Framework clarifies that the only learning type these digital resources serve is 'acquisition'. The great contributions of the digital world are communications and interactivity. They are ideally suited to supporting social and active learning. And yet the edtech-oriented inventions remained stubbornly devoted to the presentation of ideas and knowledge, rather than the opportunity to interact with them—as if we had incorporated only reading, and not writing, as educational technologies. The tools and resources to support social and active learning had to rely on adaptations of innovations for other contexts, such as business and leisure activities. Not even

Table 6.1 The relationships between the seven OU learning activities and six Conversational Framework learning types

Open university pedagogy profile 'learning activities'	Conversational framework 'learning types'
Assimilative (attending and understanding content)	Acquisition
Information handling (gathering and classifying resources or manipulating data)	Investigation/Inquiry
Adaptive (use of modeling or simulation software)	Practice
Communicative (dialogic activities, pair dialogues, or group-based discussions)	Discussion
Productive (construction of a written essay, new chemical compound, or sculpture)	Production
Experiential (practicing skills in a particular context or investigation)	Collaboration, in teamwork
Assessment, (a spread of activities across the course)[7]	Production

the complex virtual learning environment platform, which was developed specifically for education, is sufficiently complex to support the entire Conversational Framework. It does not enable the teacher to design a tool for practicing achieving a learning goal based on informational feedback that enables them to improve their performance—you cannot easily make an interactive game, for example.

Instead, teachers must develop their own sequence of teaching–learning activities that employ different kinds of digital tools and resources, to optimize the learning experience.

Learners need to develop the relationship between their concept and its implementation in practice over time. The Conversational Framework suggests that this requires more than learning through acquisition—reading, watching, listening—important though that is. They also need to be guided in social and active learning. Teachers support this by designing each learning activity, learning session, and series of learning sessions by guiding their students to be social and active learners. To help them in this process, we created the Learning Designer tool as a tool for putting the Conversational Framework into practice.

[7] Assessment is something done by teachers, on the basis of the spread of different activities done the learners, i.e. their 'productive' learning activities. So I represent these two 'learning activities' as the same 'learning type', 'production'.

6.3.2 Development of the Learning Designer

Teachers in most sectors have long had structures for planning and describing the way a lesson or class session should proceed, although for university lectures they often settled into a standard 45-min lecture with 10 min for questions, still retained across much of the university sector. Small group tutorials have been diminishing rapidly with the expansion of student numbers. The more practice-oriented subjects include lab or studio sessions, and fieldwork, and all subjects requiring assignments of some kind. The design of the student's learning process beyond the classroom, however, is not in focus for most teachers, beyond providing a reading list. 'Contact time' that is guided by the teacher has been gradually reduced with the greater pressure on university funding, so there is an increased expectation of what is termed 'self-regulated learning'—not a practice that we often teach. But it could be guided. Thus, the aim of the Learning Designer tool is to support teachers in thinking through what their students need to do to achieve the learning outcomes they intend.

The Learning Designer[8] was developed and evaluated as part of a research project, through a series of workshops with teachers from different university and college subject areas (Laurillard et al., 2013, 2018). The tool is free and open to all. It has been used in a range of courses for teachers, often run as MOOCs, as well as on-campus courses, and attracts over 700 unique visits daily, with a 32% return rate.

To be effective for learners, learning design requires an awareness of what it takes to learn, so the tool embeds the six learning types as options for the teacher-designer to select as they plan a learning session. In this way, it focuses the teacher's thinking on looking at the learning process from the learner's point of view: what are students doing in a 45-min lecture? They are reading, watching, and listening, certainly, but according to the Conversational Framework that will not be sufficient. The tool invites them to think about what else their students should do before, within, and after the class, and how their activities will help them work together with other students, and as individuals. Each teaching–learning activity can have several learning types in sequence, where each one is defined in terms of its learning type and other pedagogic features, and explains what the student is being asked to do. Figure 6.3 shows an extract to illustrate the Designer tab.

This is a thinking tool for the teacher, designed to help them think through what the learner needs to do in terms of the learning outcomes, and how they should be guided to work. Once complete it can then be exported to Moodle, for example, where all the information is preserved, and the teacher can then embed the files and hyperlinks from the attached resources into the platform.

Because teachers are now have to also think through how best to balance what they do online, within and beyond class, and which digital tools and resources will help them, these must also be selected as part of the process. And because students' time is very pressured at university, across all the courses with assignments they are doing in parallel, the time needed for each activity must be as carefully planned as it is for a class session.

[8] https://www.ucl.ac.uk/learning-designer/.

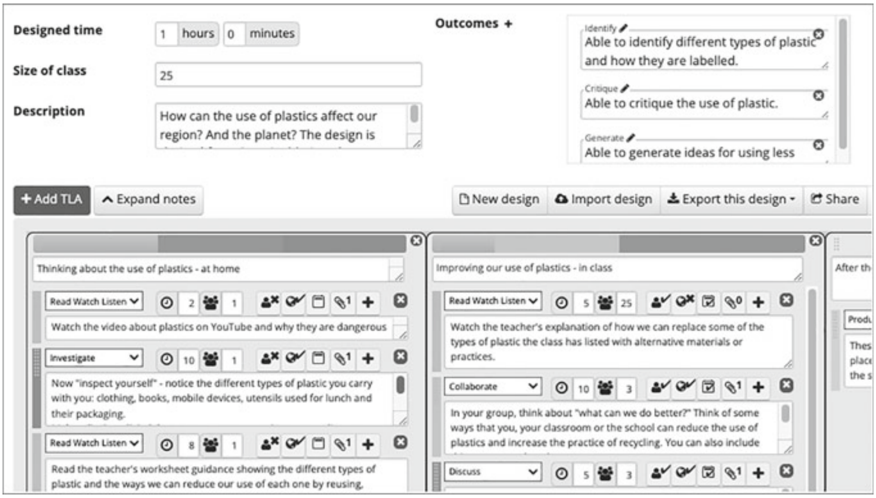

Fig. 6.3 Extract of a learning design in the Designer screen, representing the learning type, duration, group size, teacher presence, online/not, synchronous/not, resources attached, and guidance text for the student (color-coded bands for learning types appear in grey-scale)

6.4 Fostering Collaboration

For collaboration between teachers to work the process must be carefully orchestrated. Given the scale of innovation needed for us to optimize digital technology the teaching community needs support of the kind that underpins academic knowledge development in general. This section proposes the kind of organizational and digital infrastructure we need if we are to include all teachers able to collaborate successfully.

However, collaboration does not happen easily, in any context, so we address this issue head-on with the idea of a ‘theory of change’ for education. It is common practice in the international charity sector, less so in research on educational change, but vital, if the intended collaboration is to be successful and productive.

6.4.1 A Theory of Change for Education

Establishing a Theory of Change for an education initiative was originally introduced by researchers in the 1980s to show that an evaluation could find out not only whether it achieved the intended outcomes, but also how it did so. Understanding how the process led to the outcomes was as important as achieving them (Judd & Kenny, 1981). For educational outcomes in specific professional areas we need a Theory of Change that guides the research planning from the initial inception to its long-term establishment in practice. Four factors define the basic requirements for a theory of change that will support a collaborative model of professional development on the large scale (Kennedy & Laurillard, 2023):

- the focus is online learning for professional development, meaning that we are working with knowledgeable professionals;
- the model must work at scale across diverse countries and cultures to meet the needs of professionals everywhere;
- working at scale entails a wide variation in local contexts, so the process must be participatory and contributory, rather than imposing a prior perspective;
- any external initiative must plan to be sustainable by the participants themselves, beyond the short-term funding period.

From these requirements we can specify the five main stages for the research and development project as.

Engage— defines with end-users the needs to be addressed in the intended learning outcomes and curricula for the course;
Develop—collaboratively creates the course as a CoMOOC (Codesigned Massive Open Online Course) with those outcomes and curriculum topics;
Extend—publishes the course on a platform that includes a wide range of teachers now able to localize the ideas and solutions;
Embed—uses activities in the course to embed the course ideas and resources as blended learning courses in local communities;
Sustain—builds on the communities generated to continue as mentors and educators, who then create the revisions for each stage in the light of ongoing feedback

Figure 6.4 represents the stages of the Co-Design Theory of Change quite simply, clarifying the influences and feedback for each stage, and instantiating each stage in terms of its activities, actors, and the types of impact each creates (Kennedy & Laurillard, 2023).

The definitions clarify the meaning of the arrows and how the iterative workflow proceeds as the project develops, and they specify the type of data to be collected to show evidence of the intended impact (Kennedy & Laurillard, 2019).

A co-design approach to educational intervention is generic enough to serve all five of the main categories of education design: product design, solution design, professional services design, infrastructure mechanism design, and policy design. In each case a Co-Design Theory of Change will guide design thinking from the initial engagement with stakeholder representatives through to organizing the sustainability of the self-improvement process for whichever level of the system is being designed.

6.4.2 The Collaborative Design Process at Scale

To keep pace with the always-increasing opportunities offered by digital methods, we need an equally rapidly developing and large scale of educational innovation

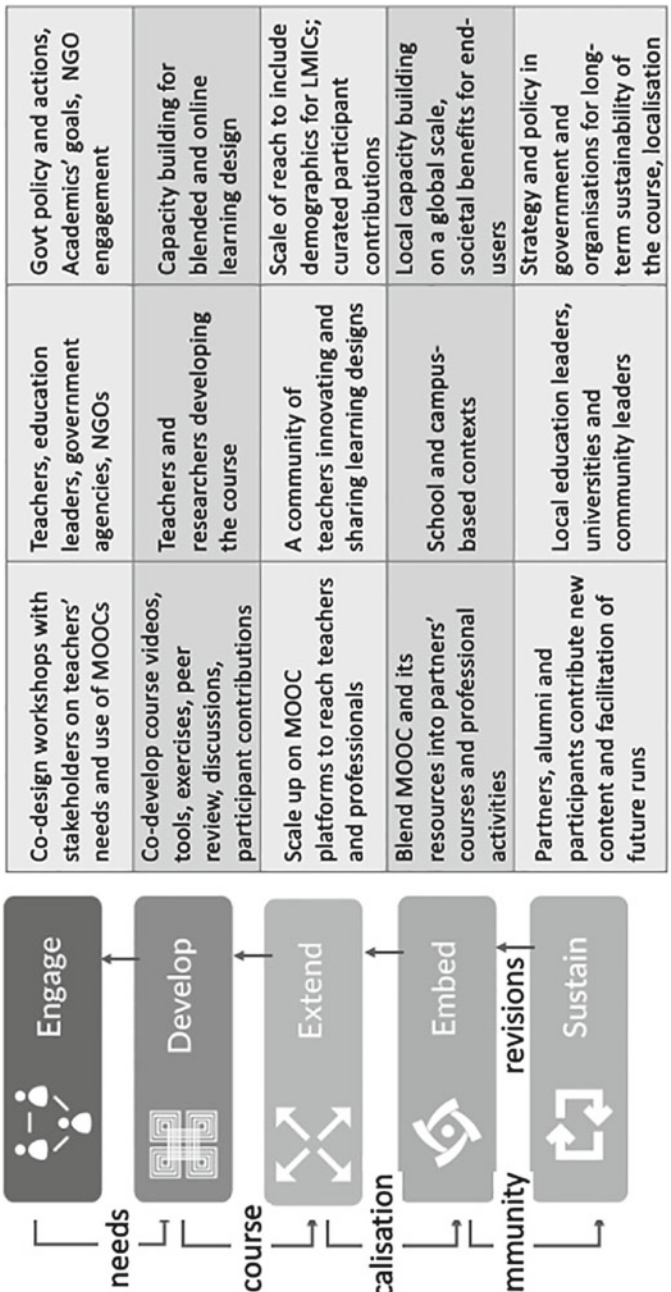

Fig. 6.4 An iterative Co-design theory of change for TPD

for learning products. This is feasible only through collaboration, just as knowledge development in science and scholarship has needed the infrastructure of academic journals and conferences, which enabled the explosion of knowledge and innovation over the last few centuries. In education we have no equivalent. Teachers are not supported for this: they have no time accorded to innovation, and no infrastructure for sharing what they come to know and discover as they teach. They will never have the time needed to read, experiment, and write academic papers.

With the Learning Designer, we now have an appropriate and equivalent form of pedagogic knowledge development that has many of the design features of the academic journal:

- The Browser screen organizes and partly curates the designs contributed by the teaching community, enabling teachers to build on the work of others.
- The Designer screen supports their design thinking, based on the theoretical underpinning of the Conversational Framework.
- The Analysis screen supports reflection on the quality of their design.
- The Share option for a learning design supports a peer review process to improve it.
- The Browser screen also provides the means to share their new knowledge by making their learning design public.

This is proving to be a valuable advance, but it lacks the infrastructure of the human organization involved in editing and publishing an academic journal or organizing a conference.

However, we do have the technology for that: the massive open online learning platforms, now created in many of the main languages, and available with only a little more trouble to any of the languages served by Google Translate.

The MOOC has survived the over-ambitious initial claims made for its impact on higher education and seems to have settled into a useful supplement for undergraduates and a valuable lifeline for professionals who look for development and innovation in their practice. Such platforms are therefore ideal as part of the infrastructure for the collaborative development of professional knowledge.

Many MOOCs are constructed to impart new ideas to their audience, using videos as a primary feature, but for many professionals there is great value also in learning from each other. They share the same issues and problems, they explore similar solutions, they have a lot of experience and expertise to bring to the discussions, so the social learning element is essential, emulating the academic conference. For these reasons we work mainly with the FutureLearn platform, which has always prioritized the social contributions of participants as much as the video presentations, and this enabled us to develop the format of the CoMOOC.

To engage the professional community in opening up to new ideas, and to challenging and critiquing them, it was important to extend the MOOC concept to 'co-designed massive open online collaborations', or CoMOOCs. The critical design features for a CoMOOC focus on the process in the design phase and on the format of activities in the course itself (Kennedy & Laurillard, 2023).

6.4.2.1 Design Phase

- **Co-designed with professionals**—grounded in case studies from practice, for co-designed videos.

This is the Engage stage of the Co-Design Theory of Change. Workshops with representatives of the main intended audience are organized to establish the key requirements of these professionals in terms of the learning outcomes, curriculum, and pedagogy.

They identify problems and current solutions, whose work will be filmed for the video case studies, and how to source these from a range of contexts.

The duration of the course and the study time needed per week must take into account the pressured lives of participants. Most MOOCs aim for around 3–4 h a week for 3 weeks for busy professionals.

Certification is important for many participants, so the criteria for completion must be decided. Should they go beyond the base level of completing all activities and passing all quizzes, and if so what kind of assessment would be feasible and appropriate?

- **Designed for collaborative learning**—at scale, so therefore open and online.

The platforms to be used are identified, deciding if it is important to use more than one to cover more languages, or whether using Google Chrome with the Google Translate plug-in will be sufficient to meet the inclusivity needed.

Most large-scale online platforms are free at the point of use but charge a fee for certification and continued access. Country-specific fee levels are important for inclusivity.

Collaboration means creating joint products in some way, so it is important to identify how participants will be able to share and build on each other's ideas through technologies such as the Learning Designer, as appropriate for the topic.

6.4.2.2 Designed Activities

- **Collaborative learning activities**—using community knowledge building for learning designs, polls, and peer review.

The sequences of steps in a massive open online collaboration must scaffold the process carefully so that all participants feel included and supported. One clear example is illustrated in the Blended and Online Learning Design[9] course, which provides guidance on creating and submitting a draft output, then runs a peer review exercise where the platform gives everyone who submits the chance to do two reviews of other submissions. Each participant can then use the review/feedback process to improve their draft and submit it to be considered for inclusion in the 'curated designs'

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[9] https://www.futurelearn.com/courses/blended-and-online-learning-design.

section of the Browser for that course. The collected learning designs thus constitute the beginnings of knowledge building for digital pedagogies.

- **Structured discussions**—where participants are invited to take part with explicit prompts to guide the discussion.

Most MOOC platforms provide a space for discussion, but this is often rather separate from the content and practice activities. The FutureLearn platform foregrounds discussion in its structure as it provides the opportunity to comment on every step. This is not simply a general exhortation to 'discuss among yourselves', but a prompt or guide to discuss some specific issue raised in the video or exercises (Laurillard, 2016). As a result discussions are more likely to have substantive content, or to elicit ideas, critiques, and potential solutions.

The significant contribution that platforms such as FutureLearn make is to orchestrate the collaborative innovation of learning design across a global professional community. Whether the topic is education, or climate change, or migration, or business development, the problems are common to most professionals in their field, and the solutions will be useful, especially when modified to local needs in the discussions and collaborations. The platforms do not offer, however, sites where the articulation of those solutions can be curated and stored for future access. This is why we must develop the appropriate formats for sharing solutions, such as the Learning Designer.

6.4.3 Co-designed Interventions in Teacher Professional Development

The development of the co-design approach in the context of teacher professional development (TPD) began with a Blended Learning Essentials[10] program to provide a series of MOOCs for the vocational education sector. The initial research used surveys and interviews with teachers and educators in the sector to establish the critical issues they were facing in introducing blended learning into further education colleges. Lack of support for professional development of this kind was the major issue, and the principal gap to fill.

The evaluation study used the quantitative data from platform analytics that recorded how participants engaged with the courses and from within- and post-course surveys, while the qualitative data came from open-ended survey questions, discussion comments, and interviews with volunteer participants. Interestingly, a large minority of enrolments came from teachers in primary, secondary, and university sectors, despite the clear emphasis on vocational education. This was a clear demonstration of the continued lack of TPD on blended learning across all sectors.

The main lessons learned from the project were that the biggest challenges are (a) local support for teachers to complete the course, and (b) its sustainability in the longer term. These outcomes contributed to the development of the stages of

[10] https://www.futurelearn.com/courses/blended-learning-getting-started.

Engage, Embed, and Sustain in the Co-Design Theory of Change, along with the basic idea to Extend this type of TPD to all teachers, given the lack of such support (Kennedy, & Laurillard, 2019). The importance of co-development in the development stage derived from the great value contributed by case-study videos of existing practice in blended learning in the vocational education sector.

This experience informed a series of further collaborative design projects to develop MOOCs on blended learning for teachers working in challenging contexts, such as migrant communities. Here, the initial workshops in the Engage stage showed that despite the issue of technology access, there was a clear potential for co-designed digital learning to meet teacher professional development needs. What they needed most was to make refugees decision-makers, and to genuinely involve the whole community—Lebanese, Palestinian, and Syrian teachers and teacher trainers—in the co-design of a MOOC (Kennedy & Laurillard, 2019). The most recent is the *Teaching Online*[11] course, developed in Arabic on the Edraak platform to serve teachers in the Middle East and North Africa (MENA) region. Building on the experiences with previous projects it was designed to provide 10 units in each of two weeks, where a unit typically included:

- a short video to show existing innovations by local teachers using digital pedagogies, and theoretical principles for blended and online learning design,
- an interactive exercise using digital tools for teachers to localize the generic pedagogic design principles for student engagement, student–teacher interaction, and active learning, and then share their designs,
- a short article to follow up on theory and useful links to digital resources, and
- a discussion forum to articulate their responses to key questions and issues.

The evaluation study for *Teaching Online* is illustrated in the next section, which shows how this approach can provide evidence of collaborative design-based thinking in the context of teacher professional education.

6.5 The Evidential Basis for Collaborative Design-Based Thinking

This section begins with the evidence from practice, where teachers' experience of a CoMOOC, the Teaching Online course described above, was evaluated against the five levels of the Value Creation Framework (Wenger et al., 2011): Immediate, Potential, Applied, Realized and Reframing value, to analyze the data in terms of the different kinds of value experienced by the participants (Littlejohn et al., 2022).

We then consider the evidence of the viability of this solution for professional development, based on this and other CoMOOCs evaluated in a similar way, but with the teaching costs tracked and analyzed as well as the learning benefits.

[11] https://www.edraak.org/programs/course/ucl-mooc1-v1/.

On the basis of the experience of teachers' responses to both the Learning Designer tool and the CoMOOC model, the final section imagines the future trends for these technologies, especially in the light of the new large language models from AI research.

6.5.1 The Evidential Basis for Teacher Collaboration on Learning Design

The Teaching Online Course was developed at the beginning of the Covid-19 pandemic, in 2020 as a rapid response to the urgent need for all teaching to be carried out remotely. The 2-week course was in Arabic on the Edraak platform and offered free access to teachers in any country. Almost all the 23,000 initial enrolments came from countries across the MENA region, the largest group from Egypt, with 6,900, then Jordan with 6000, Syria with 808, State of Palestine with 665, and Lebanon with 553.

The platform data showed that teachers choosing to engage actively with a course numbered 12,300, or 48% of those enrolled, which is common for a MOOC, where there is no up-front fee, and no cost to not engaging, which is more comparable with the enquiry stage of students for traditional campus university courses, than with the enrollment stage that requires the fee.

Of those who engaged actively, 17% (2076) responded to an in-course survey and 23% of those (472) responded to a further post-course survey to follow up on how they had or had not used the course in their teaching. Responses to the demographic questions showed that 51% were female, and 84% were working from home (April to July 2020).

This sample is therefore not selected at random and is not controlled for demographic characteristics, so cannot be seen as representative; the data can only demonstrate the experience of the value of the course for this particular group.

It is very difficult for educators and researchers running these courses to collect data about those who disengage or leave. There is only one source of data from people who begin the course but choose to leave, available on the FutureLearn platform where data is collected from the ~1% of participants who respond to a very short 'leavers survey' with the simple question: why did you leave?', selecting from seven options:

(1) The course required more time than I realized
(2) I don't have enough time
(3) The course wasn't what I expected
(4) The course won't help me reach my goals
(5) The course was too easy
(6) The course was too hard
(7) I prefer not to say.

of which the first two are selected by the great majority on our courses. Unfortunately the Edraak platform runs no such survey. For ethical reasons, our MOOC platforms do not allow researchers to contact individual learners directly, unless they have responded to an in-course survey to agree to be contacted.

In addition to the demographic questions, the in-course, and follow-up surveys collected both quantitative and qualitative data on participants' experience of the course.

6.5.2 The Evidential Basis for Teacher Collaboration on Learning Design

The qualitative data open answers were analyzed according to the themes defined by the Value Creation Framework as giving the five types of value to participants.

The most important value outcomes for a CoMOOC are Applied, Realized, and Reframing value, because this is where the course is making a direct difference to participants and their students. The question 'Has the course changed the way you and your colleagues think, or future planning for online learning?' indicates the Applied value of being able to use the concepts and skills from the course. The question had 94% 'Yes' responses and 21% offered explicit examples of applying the course ideas and approaches in their own practice:

> I became more aware of some aspects of planning and more aware of supporting the class with some educational programs.

> I looked for ways in the classroom to now use and train technology more often.

or for innovative actions such as:

> Developing solutions that were previously complex and have no solutions.

> Moving from traditional methods to distinctive innovative methods of introducing the student and the parent in the educational process.

The Realized value was tested through the teachers' sense of the value to their students: 'To what extent do you think your students have benefited from the knowledge or skills you acquired in the course?' on a scale of 1 to 5. The justifications for selecting 'a lot' or '4' were analyzed from the written responses. Of these, their experience of the value to their students showed quite explicit ways in which their revised teaching changed the student experience:

> Employing serious strategies in creating a real learning environment.

> By using modern programs, which helped students to understand and comprehend more.

– and had clearly beneficial effects on the students, such as:

> Everyone was ready and waiting for the next day's tasks.

Students 'Response, Questioning, Students' Common Interest.

– while many teachers commented that only 3 months after the course was too early for them to tell.

Some of the lower scores came from teachers who were very aware of the disbenefits of lack of access, for example:

Unavailability of Complete Resources.

Because the opportunity for distance education in my country is very weak and limited.

A TPD course can do nothing about access. It can only help to create a teaching community that understands the potential value of blended and online learning, and therefore may help to make the case for better access to the technology.

Further detail on Realized value comes from the question *'How has this course helped you in teaching online? Can you give us specific examples?'*. 41% of the answers gave quite specific examples, e.g.:

Teaching via the zoom technique had very positive results in the baccalaureate degree.

A new experience, my style has helped many people to experience distance learning. The attendance became large over time.

Examples of Reframing were also given in response to the question 'Has the course changed the way you and your colleagues think …?'. 94% responded 'Yes'. It is a tribute to the massive educational experiment that the pandemic lockdown forced on teachers that it made such a dramatic shift in perspective possible.

32% of open responses showed that the course made them rethink their ideas, as teachers could now envisage a major change in the conduct of education:

Changed my view of modern technology and its importance in today's school.

Expanding horizons and realizing the importance of distance education.

Online learning is a vision for the future worth experimenting with and creating.

These comments reflect the high rating teachers gave the course for new ways of thinking and planning. They demonstrate that in the context of a real-world imperative to change radically the way they teach, many teachers are remarkably adaptable and willing to experiment, even in the adverse circumstances of a pandemic and inadequate infrastructure.

From these results we can see that the Theory of Change stages of 'embed' and 'sustain' have been reached to some degree. The evaluation led to further collaboration with Lebanese University teachers and their own students, which enabled the team to establish the teacher needs for the next version of the course, including more practice-related videos and exercises, more sharing of digital resources and new practices, and explicit guidance to all participants on how they can embed and sustain its value.

The main insight from the succession of CoMOOCs developed for TPD is that this model is feasible for the collaborative development of professional knowledge on the large scale. The MOOC platforms we now have, and the widespread use of the Learning Designer tool for articulating new solutions for digital pedagogies, provide an organizational infrastructure for teachers to share and build on each other's pedagogical design thinking. Moreover, the use of these digital technologies in all education contexts, including some of the most challenging, is feasible.

These are the early stages of a new collaborative approach to learning design solutions, but the experiments so far show that teachers are willing to embrace these kinds of technology solutions, and the collaborative and innovative learning designs they inspire.

6.6 The Financial Viability of the Comooc Model

For professional development, especially online and via MOOCs, it is important to understand course costing, because it is importantly different from teaching students in campus courses. Without the need for personal nurturing and support, which large-scale courses do not provide, the cost structure is very different, being focused almost entirely on fixed development costs (videos, course design, quizzes, etc.), with the variable costs (per student costs, of which there are none), and recurrent costs of re-runs (rebuilding the course on the platform) being proportionally very low. A MOOC for professionals with 1,000 participants often has similar educator involvement in discussions as one for 10,000, because the focus is on peer interaction as much as with educators. Some CoMOOCs have invited completing participants to rejoin as volunteers in later runs in the 'mentor' role. This works well for them as it continues their own professional development, and is certified by the educator, which is often valuable for their CV. Their input was often mentioned by participants as one of the valuable features of the course, and the practice enables the more affordable sustainability of the course.

The business model for MOOCs can therefore be very good, in terms of educator costs vs scale of reach. The critical variable is the proportion of participants who pay a fee for certification and permanent access, and the pricing of this must balance the affordability for most participants against the number who will pay. For some courses the certification has been very attractive for their professional development context, and they have built up significant profits as a result.

If global institutions and agencies, local and national governments, and INGOs, were to embrace the CoMOOC model they could provide opportunities for professionals in all the UNSDG fields to upgrade their knowledge and share tested innovative practices of the kind we need if those goals are ever to be met.

This is the technology that could deliver affordable interventions for achieving all the ambitious goals we have set.

6.7 Future Trends in Learning Design

It is unnerving to predict the future trends in learning design while AI thinking dominates and distracts decision-makers at all levels, and while its focus is not the wellbeing and optimal conceptual and skill development of the student. In terms of the Conversational Framework the initial excitement about ChatGPT and similar large language modelers is hard to interpret as relevant to education.

It cannot act as the teacher, because the teacher should be a reliable source of information and explanation, which ChatGPT is not. It is not a peer because it 'knows' a great deal more than a peer learner would know, and has an unbalanced advantage in that respect, because it can make use of billions of existing texts in seconds. However, it does not easily 'learn' from the learner because it is not programmed to remember the previous encounter it had with them.

At best it is a form of learning environment, though not an intrinsically educational one. It does not set any goal, so cannot evaluate the learner's action in relation to a specific practice goal as we would in education. In our more familiar social and physical world there is no defined goal either, but there certainly are goals that the individual as a learner is trying to achieve within those worlds. We learn how to operate within them by reacting to what we get back from that environment when we act on it—babies, children, and adults all learn how to navigate the social and physical worlds they interact with.

In a similar way, students learn a lot by interacting with a non-educational digital world, such as the internet. They must learn that on the internet there are false friends as well as well-sourced knowledge and information sites, although the internet itself does not teach them this. They must learn this inconvenient fact about ChatGPT as well. On the internet they can usually check the sources, whereas ChatGPT sometimes invents its sources, and that fault may be more difficult to recognize.

Learners can learn how best to interact with a chatbot to their advantage but must also take responsibility for how they evaluate what it says. It is emphatically not playing the role of either a teacher or a peer. A teacher may invite students to use it as a learning environment, but that activity will be embedded in a learning design that prepares them for the task and follows through with discussion and reflection on what they found—just as you do if you send them to the internet to find something.

Could these large language modelers help with learning design? The design produced by the Learning Designer tool is simply a structured text document, after all. AI colleagues thought it would be a good idea to build AI into the Learning Designer to discern similar patterns of design, so that if it recognized you were beginning such a pattern it could offer others like it. AI has been very good at advising 'if you like that, you'll like this'. But that is very convergent thinking, which is not what we need. It would be helpful to have suggestions for designs that are built for similar learning outcomes but are very different from what I am creating. That does not require AI—just standard if–then rules, of no interest to AI colleagues. It would be more valuable if AI could help teachers and students to be more critical, creative, and divergent in their thinking.

It is unlikely that AI as it is envisaged at present will revolutionize a relatively nascent and under-documented area such as learning design. In any case, learning design is fun—creative, challenging, and rewarding. Why take the fun out of teaching?

It would be preferable to aim for the deep engagement of teachers designing the future trends in education. They are the people who are closest to and who best understand the students and their needs. They are bypassed and patronized by everyone who thinks they can fix the problems of education. Our best hope is that the future embraces their vast knowledge, care, and commitment to the improvement of education. This chapter attempts to clarify how that vision could be achieved.

6.8 Discussion and Implications

This book addresses some key questions for the future of education, and within it, this chapter has some contributions to make to each one.

6.8.1 How to Overcome Education Challenges by Adopting a Design Thinking Approach

The critical universal challenges identified in the UNSDGs include 'universal lifelong learning' for SDG4 on education. In 2023 we are halfway to the 2030 target year for these goals, and yet 103 million youth worldwide still lack basic literacy skills. SDG4 is a massive challenge, and the lifelong learning part of it underpins every other SDG as well, in terms of the professional practices that must be changed and redeveloped in the light of scientific understanding and advances.

A massive challenge requires a massive response, which is why this chapter has focused on the large-scale education platform as the only form of education commensurate with the challenge ahead. The argument is that the co-design model for MOOCs has been shown to be capable of engaging tens of thousands of teachers, even those working in the most challenging contexts, in using new technologies to improve their learners' chances. If this can be done with very low-level research funding, the major INGOs and government ministries of education can deploy just a fraction of their funding to the end of harnessing the expertise of the global teaching community to build the digital learning design knowledge we now need if we are to get close to those ambitious goals (see Sect. 6.5.2).

6.8.2 How Do Researchers, Educators, Instructional Designers, Consultants, etc., Apply Design to Solve Educational Problems and Issues

The principles of design thinking are common to all the levels of educational design (see Sect. 6.4.1). This chapter has focused on learning design. Among the many problems we have yet to solve is: how to optimize digital technologies in teaching and learning so that every learner can achieve their learning potential? This means widespread innovation, experimentation, and sharing of ideas, harnessing all the expertise and experience of the global teaching communities. Digital technologies, such as the Learning Designer tool and the CoMOOC model have the capability and reach to support exactly this kind of solution (see Sects. 6.3.1, 6.3.2, 6.4.1–6.4.3).

6.8.3 What Are the Best Practices for Effective Educational Design

The argument here is that the best way is to emulate the knowledge building infrastructure of science and scholarship by enabling teacher collaboration, peer review, and publication, and sufficient time to engage with this approach. This is how we find out what works, and how to localize it, and then spread the news of effective design solutions across the world (see Sects. 6.5.1–6.5.3).

6.9 What Are the Implications for Learning Design of AI's Large Language Models for Human Interactions

Firstly, in the context of education they are not yet sufficiently reliable to play the role of teacher, and are not designed to act like a peer. They could be deployed by a knowledgeable teacher as part of the learning environment. However, they should only be designed into learning sessions by a teacher.

Secondly, because students will find their own ways of using such tools, the effective use of them must be part of the curriculum, as part of their digital literacy and twenty-first-century skills development, as is the use of the internet.

At present, I see no role for them in the creative and innovative development of more effective learning designs.

6.10 Conclusion and Recommendation(S) for Future Work

These final reflections pull together the studies covered in this chapter, to offer a good foundation for future research.

6.10.1 Key Concepts for Collaborative Design

A collaborative approach to design thinking in education is essential because there is so much distributed expertise that must be harnessed to create solutions to the massive challenges we face. The key concepts are italicized in the summary below.

A theory of change must plan to engage with the communities that need support, whether in challenging situations such as migration, and remote areas, or in teachers' expertise such as special needs, numeracy, and literacy, the foundations for individual educational success, or in the new digital pedagogies that require so much attention to innovation.

The remaining stages of the proposed theory of change use collaborative design to develop the intervention, use large-scale learning platforms to extend it to the scale of the global audience, embed the innovative solutions in local adaptations, and partner with local institutions and governments to sustain the benefits of the intervention.

The success of the intervention can be evaluated in terms of the five levels of the Value Creation Framework: immediate, potential, applied, realized, and reframing.

For collaboration to succeed it needs both orchestrated support such as a CoMOOC, to organize the process, and a teacher's design tool such as the Learning Designer as the means to share ideas and solutions for every type of learning design.

Because the design tool, such as the Learning Designer, guides the development and evaluation of digital pedagogies, it must be based on sound pedagogical principles, such as the Conversational Framework and its six learning types: *acquisition, inquiry, practice, discussion, collaboration, and production.*

6.10.2 Limitations of the Studies and Approach

The proposals discussed in this chapter have all been instantiated in practice, evaluated, and subject to peer review as published research papers, as referenced. Large numbers of teachers have been involved in using the Learning Designer, and several different professional communities have contributed to testing the CoMOOCs developed, numbering in total >100,000 active learners in different parts of the world. The evaluation framework showed that all five levels have been achieved with this model for collaborative professional development.

Nonetheless, this work is still at its early stages, running on a relatively low funding base (~$900,000) for both the development and the research over 5 years, and without government support. Education is an organ of the nation state, in all countries, and its future is very dependent on government policy and funding. Without policy engagement with this type of approach to the professional development we need across all the UNSDGs, it will not fulfill its potential. Another critical dependency is the digital technology infrastructure. If that does not continue to develop in ways that support education, then the future is bleak, no matter that we have the evidence of the potential of these current digital models.

6.10.3 Considerations for Education Leaders

Education leaders in educational institutions, NGOs, INGOs, and government have the responsibility to acknowledge the scale and nature of the challenges across all education sectors worldwide, from pre-school to lifelong learning. This chapter has focused on the value of collaborative learning design, and the means to achieve it at scale, because that is where the point of education resides: where every learner is able to achieve their learning potential. We only do this when we harness the knowledge of the global teacher communities and the power of digital technologies to develop that knowledge collaboratively.

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Chapter 7
Designing Future Education for All: Principles and Frameworks

Salwa Mrayhi, Mohamed Koutheair Khribi, Haifa Belhadj, and Mohamed Jemni

Abstract Education is currently experiencing a paradigm shift at an accelerated pace that brings forth a range of mega-challenges for educators. This shift is primarily driven by the unprecedented technological advancements, the evolving learner needs, and the recognition of the importance of inclusivity and learner-centred approaches. Teachers as well as learning designers play a vital role in addressing these challenges by designing innovative and inclusive learning experiences that prepare students for the complexities of the future. This requires among others, a commitment to lifelong learning and continuous professional development, prioritizing effective technology integration with accessibility in mind, and a deep understanding of learners' diverse needs to provide personalized learning experiences, embracing diversity, equity, and inclusion. This chapter explores the principles, and frameworks involved in designing future education to meet inclusivity and accessibility requirements in a rapidly changing landscape. Within this context, the chapter presents an analysis of educational design approaches, discusses issues related to inclusivity and accessibility in education, and highlights the need to incorporate universal design for learning principles, harnessing innovative technologies and Artificial Intelligence (AI), in creating supportive and engaging learning environments that enable equitable access and opportunities for all learners.

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7.1 Introduction

It goes without saying that education is witnessing radical changes, where tremendous advancements in technology, globalization, and social dynamics are reshaping the whole landscape (Pavlova, 2005). Such changes profoundly influence multiple facets, including the design of learning content and learning experiences, learning and teaching practices, as well as teacher roles and required competencies. On that premise, educators must acclimate to this increasingly complex and rapidly changing education landscape by integrating emerging technologies efficiently, prioritizing inclusivity and diversity, adopting learner-centred approaches, and engaging in continuous professional development (Khribi, 2022).

The Sustainable Development Goal 4 (SDG 4) in the 2030 Agenda has set forth a vision of providing inclusive and equitable quality education for all (Murdoch et al., 2023). Achieving this necessitates, among other things, the implementation of innovative approaches to educational design. The Fourth Industrial Revolution (4IR), and recently the COVID-19 pandemic have further highlighted the urgency of reimagining education harnessing the great potential of technology to ensure inclusive and accessible learning experiences (Chigbu et al., 2023). In such difficult circumstances, online learning has emerged as a pivotal tool to maintain the right to education for all. Ever since the pandemic, there has been a continuous growing adoption of digital learning and online education practices worldwide, and consequently a significant increase in attention has been given to education design (Haleem et al., 2022). Indeed, it is commonly recognized that well-designed learning experiences not only enhance the quality of teaching but also greatly improve the learner's overall experience. Moreover, designing for online education to be fully accessible and inclusive must be thoroughly undertaken in a different way than face-to-face education in a bid to achieve a quality learning experience for all (Rapanta et al., 2020). From this standpoint, designing inclusive and accessible learning experiences harnessing the full potential of emerging technologies, represents a crucial aspect of education in today's educational landscape.

This chapter underscores the critical significance of inclusive design in education, particularly within the context of emerging technologies and future trends. It focuses on answering the following key questions: What are the commonly used approaches for design in education? Can these approaches serve all learners, regardless of their abilities and diverse needs? How to overcome design challenges in education addressing inclusivity and accessibility? Lastly, what are the required competencies for teachers and designers to solve educational problems and issues towards designing more inclusive and accessible education for all?

The remainder of this chapter is structured as follows: Sect. 7.2 presents background information on educational design, and explores the most common educational design approaches, explaining their features and potential limitations. This analysis emphasizes the imperative of considering inclusivity and accessibility when it comes to design for all in education. Section 7.3 discusses the incorporation of universal design for learning (UDL) principles and examines the necessary relevant competencies for teachers and designers to create more inclusive, accessible, and engaging learning experiences for all. Section 7.4 sheds light on the potential of emerging technologies, such as Artificial Intelligence (AI), as a tool in the learning design process, and explores various ways in which learning designers can harness AI to foster the fulfilment of accessibility and UDL requirements. Section 7.5 discusses the conclusions of the chapter and suggests future work.

7.2 Demystifying the Design for Education

In today's rapidly evolving educational landscape especially with the growing adoption of digital learning and online education practices, attention to design for education has increased, as it was shown that it contributes to improving learners' experiences and enhancing the quality of teaching. The terms "Instructional Design", "Learning Design", "Design for Education", "Learner Experience Design", and "Learning Activity Design" are generally used interchangeably in the literature, to describe, analyse, and inform the activity of designing educational instructions and creating engaging and effective learning environments (Sayed Munna & Kalam, 2021).

To understand the philosophy of design for education and its different theories, approaches, and frameworks, it may be interesting to start by exploring and distinguishing the different key terms used in the field of education design.

7.2.1 Terminology and Definitions

There have been many attempts to depict clearly the terminology used to describe design in education. In the following, we provide the commonly used definitions for the terms.

7.2.1.1 Design Thinking

The lexicon of education has recently assimilated the concept of "design thinking", denoting a nonlinear, student-centric methodology for engendering pedagogical solutions tailored to learners' needs (Mohamed, 2023). This is particularly relevant within the burgeoning of online learning design. As Elliot and Lodge espouse, equipping educators with design-oriented skills and knowledge equips them to better contend with students' evolving needs in crafting adaptive educational experiences (Beligatamulla et al., 2019). By embracing the principles of human-centred design thinking tenets, practitioners can surmount contemporary educational challenges and craft bespoke solutions fitting the heterogeneous demands of today's complex scholastic milieu (Kimbell, 2015). Design thinking can be used to develop novel pedagogical

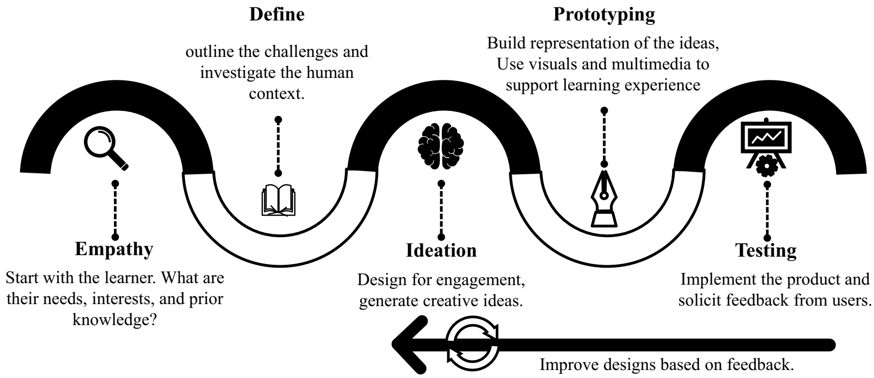

Fig. 7.1 Design thinking's five principles (Maphosa et al., 2023)

approaches, instructional materials, and assessment tools that are more effective and engaging for learners. The design thinking process, as outlined in Fig. 7.1, consists of five key stages: empathy, defining problems, generating ideas, creating prototypes, and testing to form more personalized and engaging educational experiences.

7.2.1.2 Learning Design

The term "learning" is often associated with learner-focused pedagogical strategies. These strategies are informed by conceptual, intrapersonal, and interpersonal change (e.g. cognitivism, behaviourism, constructivism, social-constructivism, and connectivism learning theories). According to Conole and Wills (2013), learning design stands as a methodology that enables teachers or learning designers to make more informed decisions in developing learning activities and interventions and make effective use of appropriate resources and technologies.

It can be considered as a multifaceted problem-solving process focusing on learners and providing answers to determining what is to be learned and why, for whom, in what context, and how learning might be best supported through adopting appropriate pedagogic strategies that optimize the affordances of various technologies. It includes planning, developing, and implementing effective learning experiences and involves the application of learning theory principles to create engaging educational materials, activities, and assessments that support the learning outcomes. The learning activities are aligned with the outcomes and the assessment. When designing a course, learning designers select the appropriate activities that help achieve the learning outcomes, and the evaluation is designed to assess the achievement of the learning outcomes relative to the learning activities and course content.

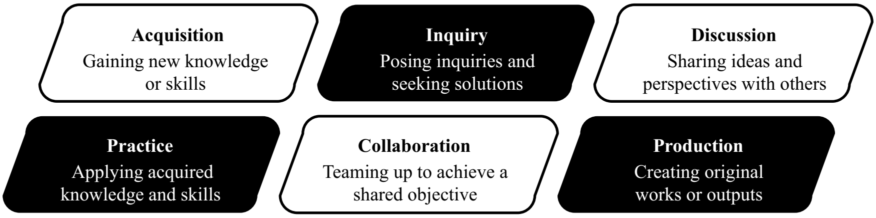

Fig. 7.2 Learning types (Laurillard et al., 2018)

7.2.1.3 Learning Activity Design

According to (*New* Learning, 2023), learning activities "are activities designed or carried out by the teacher to bring about or create the conditions for learning" (Laurillard et al., 2018) classified learning activities into six types: acquisition, inquiry, discussion, practice, collaboration, and production (Fig. 7.2). Learning activities play an important role in student learning and engagement, so they should be well designed and planned.

In the literature, a precise definition of "Learning Activity Design" remains elusive. This term is predominantly employed to guide the learning design process, emphasizing learner engagement, and a learner-centred approach. With that being said, we may define learning activity design as the process of selecting, planning, and organizing the learning activities that students will need to engage in to achieve and demonstrate the intended learning outcomes. The design of learning activities typically takes into account various factors, such as the learning objectives, the target audience, the subject matter, the available resources, and the forms of assessment to be used. The activities themselves may assume various formats and can include whole class, individual or group work, hands-on tasks, discussions, problem-solving exercises, case studies, simulations, role-playing, projects, and more.

7.2.1.4 Instructional Design

The term "instruction" is related to the act or practice of instructing or teaching. It focuses more on the teachers, what they do, and how they convey material. Instructional design (ID) predates the concept of learning design, although there continues to be considerable debate over the extent to which the two differ. ID is the process of creating and improving learning experiences that are effective and engaging. The goal of ID is to help learners achieve their desired learning outcomes (Allen & Jackson, 2017). According to Reiser (Reiser & Ely, 1997), ID refers to "The theory and practice of design, development, utilization, management, and evaluation of processes and resources for learning".

ID takes the curriculum offered by the teacher and turns it into materials (instructions) with which the learner will engage. Accordingly, the focus is more on changing and improving instruction in order to achieve the desired learning outcomes. To this end, suitable learning theories (e.g. socio-constructivism), methodologies (e.g. Analyze, Design, Develop, Implement, and Evaluate) modalities (from traditional face-to-face to innovative e-learning methods), as well as a wide range of technologies (e.g. chatbots) and interactive media (e.g. video games) need to be selected and applied to deliver appropriate learning resources and experiences. It carefully considers how students learn and what materials and methods will most effectively help them achieve their academic goals.

7.2.1.5 Curriculum Design

Curriculum design (CD) is a deliberate and systematic process of planning educational programs, courses, and learning experiences to achieve specific learning outcomes. It considers the needs of students, educational standards, and the dynamic nature of the learning environment (Harris et al., 2009). A well-executed curriculum design ensures that educational experiences are meaningful, relevant, and aligned with educational goals. It involves stages such as needs analysis or assessment, curriculum planning, content selection and organization, instructional design, and evaluation. Collaboration among educators, subject matter experts, and all involved stakeholders is essential for a comprehensive and effective CD (Sife et al., 2007). Learner-centred approaches, differentiation, personalized learning, and inclusion are integral elements of effective CD, aiming to address the diverse needs, learning styles, and cultural contexts of students (Waite et al., 2014). Technology integration plays a transformative role in CD by enhancing instructional delivery, promoting active engagement, and expanding learning opportunities.

In the comparative table below and based on the aforementioned descriptions, we outline the key characteristics of the terms: Learning Design vs. Instructional Design vs. Curriculum Design based on different aspects, highlighting their distinct focuses and considerations (Table7.1).

7.2.1.6 Learning Design Versus Instructional Design Versus Curriculum Design

As shown above, it may look somehow confusing to differentiate between the three concepts (especially learning and instructional design), as all of them refer in brief to the process of designing and developing teaching and learning resources and activities, applying principles of different learning theories in order to enhance students' learning practices. After all, many professionals in the field of education design, use the terms instructional design and learning design interchangeably, recognizing that both involve designing effective learning experiences. However, it is important to emphasize that instructional design focuses more on the teaching perspective and emphasizes the process of creating effective instruction, centred around the design of content and development of instructional materials and activities. It is commonly aimed at a specific set of learning objectives, and its impact is generally evaluated at

Table 7.1 Learning design versus instructional design versus curriculum design

Aspect	Instructional design	Learning design	Curriculum design
Focus	Design effective instructional materials and activities for learners	Design engaging and meaningful learning experiences for learners: overall learning experience and context	Design a comprehensive plan for teaching and learning that includes goals, content, and assessments
Scope	Narrow scope focuses on individual lessons or modules within a course (Micro-level) (Steyn et al., 2023)	Broader scope considers the overall learning experience and the context in which it takes place (Meso-level)	Broadest scope encompasses the entire curriculum for a specific subject or program (Macro-level)
Key Elements	Analysis, design, development, implementation, and evaluation of instructional materials and activities	Contextual factors, learner characteristics, pedagogical approaches, and technological tools	Goals, objectives, content selection and organization, assessment strategies, and instructional methods (Steyn et al., 2023)
Inputs	Learning objectives, content resources, learner characteristics, and subject matter expertise	Learner needs and preferences, educational goals, emerging technologies, and pedagogical approaches	Educational goals, subject-specific content, learning objectives, and assessment requirements
Approach	Systematic and structured approach often following instructional design models like ADDIE	Creative and flexible approach, drawing on learning theories, pedagogical approaches, and emerging technologies	Systematic approach considers the alignment of learning objectives, content, and assessments
Design Principles	Alignment of instructional strategies with learning objectives, incorporating appropriate technologies in the design, and assessment validity and reliability	Learner engagement, learner-centred approach, authentic assessments, and the incorporation of multimedia and interactive technologies in learning activities	Coherence and sequencing of content, alignment with learning goals, and differentiation to meet diverse learner needs
Outputs	Lesson plans, instructional materials, assessments, and learning activities	Learning designs Appropriate tools and technology Learning resources, activities, and assessments	Curriculum documents, learning pathways course outlines, syllabus, assessment plans, and learning objectives (Harrington & Thomas, 2023)

the level of individual courses or instructional modules. Learning design, by comparison, is more comprehensive, extending its focus beyond mere instruction to envelop the entire learning experience. Learning design (LD) integrates a wide array of influential factors such as the learning environment, the technology employed, and the roles and needs of the learners themselves. This focus allows for a more adaptive and personalized learning experience, aiming for effective knowledge construction in diverse educational settings. As for CD, it may be considered as the broadest of the three concepts with a larger scope. It encompasses all aspects of the learning experience, from overall aims and objectives to specific activities and assessments, usually for a whole course or module, and its place in relation to other courses within a program for a qualification. It is a long-term process that considers the whole structure of the curriculum, the sequence of content, and the alignment of learning objectives, content, and assessment methods.

7.2.1.7 Learning Experience Design

Learning experience design (LXD) is a human-centred and goal-directed approach to designing educational experiences that differs from traditional teacher-centred pedagogy by focusing on the experiential process of the learner (Shum et al., 2019). LXD encompasses the entirety of the learning pathway, including the environment, interactions, and support systems. It uses technology and multimedia elements such as visuals, interactive simulations, and gamification to engage learners and foster motivation and curiosity. A key component of LXD is empathy, the ability to understand and share learners' feelings and needs. By considering diverse learning needs, LXD is advancing to prioritize inclusivity and accessibility through a combination of user-centred approaches, technological innovation, and adherence to standards.

7.2.1.8 Design for Education

Design for Education can be considered as an umbrella term that encompasses instructional design, learning design, learning activity design, and learning experience design. Each of these has its own unique focus—ranging from course materials and learning activities to the overall learning environment and experience—but they are all aligned in their broader goal: to create and shape educational experiences that include curriculum development, school policies, and educational settings (Willis, 1995). What should bind these approaches together is the mutual commitment to enhancing accessibility, fostering inclusivity, and encouraging cultural responsiveness. These are not merely add-on considerations; they are integral to each design approach and manifest in nuanced ways that address the specific needs of diverse learner populations. The ultimate goal remains to design learning environments that are sensitive to the diverse needs of learners, providing the necessary tools and resources for them to achieve their educational objectives.

7.2.2 Framework for Designing Effective Learning Experiences

In literature, many frameworks have been used for instructional design, learning design, or learning experience design. Even though these frameworks differ in their nomination, they mostly comprehend similar stages and principles. It is worth noting that several frameworks have been similarly used in literature for ID, LD, or CD. ID or LD frameworks are organized and structured approaches for creating engaging learning experiences that align with learners' needs and objectives. They provide a roadmap of guidelines for instructional designers or learning designers to follow in order to deliver top-notch educational content (Janke et al., 2016). There are several ID frameworks that are used to help instructional designers make informed decisions about the best way to design and develop effective and engaging learning experiences. Though, for many instructional designers, the ADDIE framework is a useful starting point, it is a generic instructional design model that is often used as an umbrella framework for other ID models (Nalini & Raj, 2023).

The ADDIE model is a well-known instructional design framework that is widely used in the field. ADDIE stands for Analysis, Design, Development, Implementation, and Evaluation, and it provides a dynamic, flexible guideline for building effective training and performance support tools (Mohd & Shahbodin, 2015). An overview of the phases in the ADDIE model was provided in Table 7.2.

Table 7.2 ADDIE Framework

Phase	Description
Analysis	– Gather Info – Identify Audience – Define Goals – Analyse Environment
Design	– Instructional Strategies – Structure Content – Assessment Methods – Instructional Approach
Development	– Create Materials – Multimedia Elements – Assessments – Interactive Components
Implementation	– Delivery – Access to Resources – Facilitate Discussions – Support Engagement
Evaluation	– Performance Data – Feedback – Analyse Results – Identify Improvements

The ADDIE model is a foundational framework in instructional design, known for its structure and adaptable nature. Its adaptability becomes particularly potent when it incorporates principles from other frameworks like Universal Design for Learning (that we will discover in the following section), making it more inclusive for diverse learners, including those with special needs. By doing so, ADDIE moves from just a simple framework to an ecosystem that promotes inclusivity in education.

7.3 Designing Education for All

Education is acknowledged as an inherent human right in both the Universal Declaration of Human Rights (Brown & Gordon, 2016) and the Convention against Discrimination in Education (Singh, 2008). It's a critical tool for empowering people, particularly those with disabilities, who number one billion globally according to the World Health Organization and the World Bank (The World Health Report, 2001). Despite the explicit prohibition of their exclusion by Article 24 of the Convention on the Rights of Persons with Disabilities (CRPD) (Article 24—Education | United Nations Enable, 2006), people with disabilities often face barriers such as physical and digital inaccessibility, discrimination, and poor quality of education even in "inclusive" settings (Hashemi et al., 2022). These barriers contribute to lower educational attendance and completion rates among people with disabilities, highlighting the urgent need for genuinely inclusive education (Miles & Singal, 2010). Universal design in learning and technologies is then considered crucial to achieve inclusive education.

7.3.1 An Overview of Universal Design in Education

When it comes to talking about universal access to education for all, one can find in literature several terms used in different contexts and scopes, to name but a few: inclusive education, inclusive digital education, accessible education, digital accessibility, universal design (UD), Universal Design for Learning (UDL), etc. In the following, we discuss the significance of these terms in the field of education for all.

7.3.1.1 Inclusive and Accessible Education

Education aims to be inclusive by employing learner-centred strategies that assure the success of all learners, including those with diverse needs. Inclusive schools primarily use differentiated instruction to cater to each student's unique requirements. Accessible education focuses on ensuring that resources, facilities, and technologies are usable for all, particularly those with disabilities. Waddell et al. (2003) argue that accessibility is not merely about accommodating people with disabilities, but about creating environments where everyone can succeed. Therefore, several design considerations must be fulfilled to make education both accessible and inclusive. Institutions can develop safe, supportive, accessible, and inclusive learning environments where all learners can actively engage, collaborate, and excel. With this purpose, there are several considerations to fulfil, from the design perspective, to make education accessible and inclusive, including:

Universal Design (UD): Steinfeld & Maisel define UD as a transformative process enhancing human performance and social participation for people of all backgrounds (Steinfeld, 2012). The UN Convention on the Rights of Persons with disabilities states that universal design aims to be usable by all people without the need for specialized design (Ostroff, 2011). The concept transcends traditional accessibility by meeting the diverse needs of all users inherently, eliminating the need for separate accommodations. In education, this means creating materials and environments that are naturally accessible, benefiting both people with and without disabilities and contributing to a more inclusive society.

Inclusive Design (ID): Holmes defines inclusive design as a methodology focused on the full range of human diversity, aiming to include and learn from people with various perspectives (Holmes et al., 2022). Unlike UD, which aims to serve everyone, ID targets specific user groups to avoid marginalization, offering different design solutions for different people. Accessibility is a key outcome of this approach. The process involves active participation from a diverse range of users, particularly those who have been traditionally excluded, to ensure usability for all (Eisma et al., 2004). In the educational context, inclusive design prioritizes understanding each student's unique needs, thereby promoting equal opportunities and enriching the educational experience for all.

Accessible Design (AD): Steve Ballmer, the former CEO of Microsoft, stated that "Accessible design is good design. It benefits people who don't have disabilities as well as people who do. Accessibility is all about removing barriers and providing the benefits of technology for everyone" (Okunrounmu, 2021). It is a key principle in creating inclusive and user-friendly learning experiences for all. It is about levelling the playing field for learners with disabilities by ensuring that they have the same opportunities to succeed as their peers without disabilities. Designing for accessibility ensures a positive experience for all users, while providing access to information and opportunities. It reduces reliance on assistive technology, helping to create products and services that everyone can use. Following AD principles is fundamental to achieving this.

Universal, inclusive, and accessible design offers a valuable approach to crafting learning experiences that are inclusive and accessible. However, it has limitations. Implementing this approach can be complicated and time-consuming, requiring coordination among various stakeholders and additional resources. Furthermore, learners with significant disabilities may not always have their needs fully met, which may require additional support. However, these components can be combined to produce more comprehensive and accessible experiences. In addressing the challenges of designing for inclusivity and accessibility in education, it is recommended to comprehend the requirements of learners, involve different stakeholders, utilize principles of universal design, demonstrate adaptability and flexibility, use technology, provide professional development to educators, and apply evidence-based practices. It is vital to assess experiences and obtain feedback from learners and educators. By following these principles, educators can create instructional prospects that are comprehensive and attainable for all students. To ensure inclusive and accessible education, learning designers should adopt frameworks that encompass universal, inclusive, and accessible design principles, such as the Universal Design for Learning (UDL) framework.

7.3.1.2 Universal Design for Learning (UDL)

UDL is an educational framework that aims to provide all learners with equal opportunities and access to learn and succeed. In lay terms, there is a need to plan an education that targets each and every learner, rather than targeting generic standard learners, or prejudiced categories and stereotypes of average learners. On this premise, as there is evidence that people learn in different ways, a learning style can be defined as a person's preferred way of receiving information and learning (Kirschner, 2017). Accordingly, several theories and models have appeared (Kolb, VAK, Felder-Silverman, etc.) aiming to spot differences in individuals' learning, even though the learning style concept remains controversial in education. In Felder and Silverman's model, different learning styles and preferences are depicted. The Felder and Silverman's learning style denotes four dimensions of learning styles (Fig. 7.3): Sensing-Intuitive (determines how learners prefer to perceive information); Visual-Verbal (determines how learners prefer information to be presented), Active-Reflective (determines how learners prefer to process information); Sequential-Global (determines how learners prefer to organize and progress towards understanding information) (El-Bishouty et al., 2019). In order to identify learner's personal learning style, various questionnaires and tests can be used. Tools like the Index of Learning Styles developed by Dr Richard Felder and Barbara Soloman have been developed to categorize learners based on these dimensions (Felder & Spurlin, 2005). However, it is important to note that the concept of learning styles has been critiqued for its lack of empirical support, as pointed out by Snider in 1992 among others (Snider, 1992).

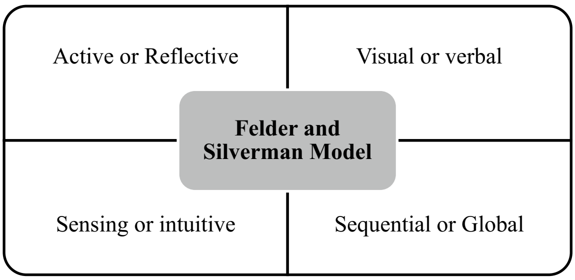

Fig. 7.3 Individual learning styles (79)

In contrast, Diana Laurillard's model doesn't centre on personal learning styles but on types of learning experiences that can benefit a wide range of students. Laurillard identifies six learning types: acquisition, inquiry, discussion, practice, collaboration, and production (Laurillard, 2013). These are not limited to individual learning preferences but are adaptable approaches that can be used universally, depending on the instructional design and the students' engagement with learning. For example, teachers can promote success for all students by offering a variety of learning experiences. Providing learners with different resources for studying a subject or different ways of demonstrating understanding is one method that teachers can use. Nevertheless, it is essential to recognize that no lone approach can cater to every learner consistently. It is essential to exhibit flexibility and adaptability, utilizing diverse approaches to meet the diverse needs of learners. This is endorsed by Todd Rose's theories (Briggs, 2019) and neuroscience research, learner variability is an inherent feature of the educational landscape. Just as no two brains are identical, students vary in their engagement, background, and methods of expression and communication. This variability can be organized into three primary brain networks: the affective network, which manages motivation and engagement; the recognition network, which is responsible for categorizing information; and the strategic network, which plans and executes tasks.

UDL is a framework designed to address this inherent variability among learners. UDL identifies three main principles that align with the three brain networks: engagement, representation, and action & expression (Fig. 7.4). By incorporating UDL, educators can provide flexible ways for students to access, engage with, and demonstrate their understanding of material, taking into account individual strengths and needs.

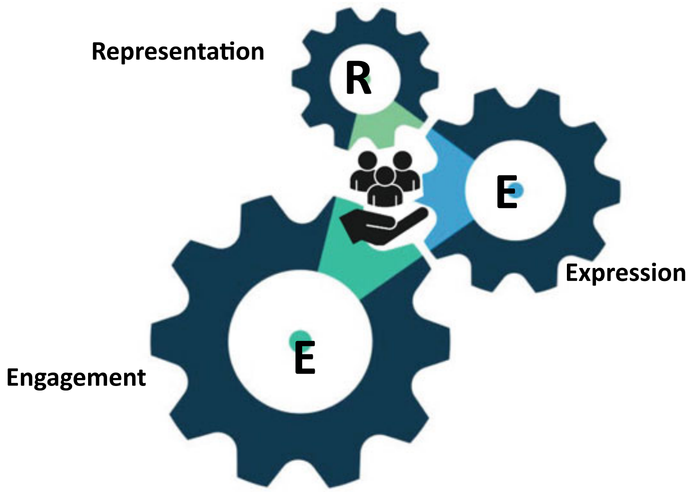

Fig. 7.4 UDL principles

Table 7.3 UDL guideline

UDL strategy and POUR guideline	Description
Multiple Means of Representation and Perceivable	Offer content in various formats, such as text, images, audio, and video, to accommodate different learning styles. Provide alternative text for images and captions for videos to make content accessible to users with visual or hearing impairments
Multiple Means of Action and Expression and Operable	Ensure that the learning platform and interactive elements are keyboard accessible, providing users with motor disabilities the ability to navigate and interact with the content effectively
Multiple Means of Engagement and Understandable	Use clear and straightforward language in instructional materials and provide intuitive navigation to support learners in understanding the content and how to interact with the learning environment

It is worth mentioning that the UDL approach is not just for people with disabilities; it is a universal framework that can benefit all learners, including those with disabilities and special needs, by removing barriers and providing multiple means of engagement and expression. Implementing UDL requires a commitment of time and resources but has the potential to create an inclusive environment where all learners can thrive. It cultivates a learning ecosystem that appreciates the diverse cognitive abilities, learning styles, and backgrounds that each student brings, effectively ensuring that no one is left behind in the learning path. To achieve an inclusive and accessible learning environment, educators and learning designers should integrate UDL principles, when designing a course, with respect to accessibility guidelines (Table 7.3).

7.3.2 *Impact of UDL on Learner Engagement and Success*

UDL plays a pivotal role in enhancing learner engagement and academic achievement. By providing a tailored and inclusive educational environment, the framework significantly improves students' motivation and engagement in learning, leading to better academic outcomes. Empirical evidence, including research studies (Al-Azawei et al., 2017) and a meta-analysis by the Center for Applied Special Technology (CAST) (Almeqdad et al., 2023), consistently supports the effectiveness of UDL in increasing both engagement and achievement for all students, including those with disabilities. In addition, Every Student Succeeds Act (ESSA) has recognized the value of UDL by incorporating it into K-12 education policy for the first time. This gives educators the flexibility to use Student Support and Academic Enrichment

(SSAE) program funds to integrate UDL principles with educational technology and assistive technology (Asakawa, 2005). The foundational concepts of UDL are derived from the principles of accessible architecture. Learning designers can effectively use the UDL framework to create captivating learning experiences, for all students. Here are some practical ways in which learning designers can apply UDL principles;

- Provide information and content in formats to cater to diverse learning styles and preferences. This could include using multimedia, visuals, audio, and text.
- Offer students a variety of options to demonstrate their understanding and mastery of the skills they have acquired. This can be done by incorporating activities that allow for modes of expression such as written work, presentations, multimedia projects, or artistic creations.
- Foster student engagement by employing strategies to motivate and sustain interest. This may involve giving choices in topics or assignments incorporating activities facilitating collaboration and discussion opportunities as well as integrating real-world connections to make learning more relevant.
- Make use of technology and assistive tools to enhance accessibility and support learning needs. This may involve employing screen readers, captioning tools, adaptive software, or interactive learning platforms that can be customized based on preferences.
- Encourage collaboration, among students while providing feedback to support their learning journey. Engaging in tasks providing feedback to peers and receiving criticism can greatly improve comprehension, facilitate social engagement, and cultivate a strong sense of community within the educational environment.

7.3.3 Educators' Competencies Towards Designing for All

Educators and learning designers should prioritize honing their proficiency in inclusive ICT, technology integration, digital accessibility, and Universal Design for Learning (UDL) to create more inclusive educational experiences availing new technologies. Spotting these competencies is crucial for planning professional development, with the ultimate aim of ensuring universal access to education for all. In the literature, we identified three profound areas: ICT, accessibility, and UDL.

7.3.3.1 Developing ICT Capabilities

Teachers' ICT competencies cover content, pedagogy, technical skills, and collaboration (Ratheeswari, 2018). Notable frameworks for building these competencies include the UNESCO ICT Competency Framework for Teachers (ICT-CFT) (UNESCO, 2018), the ISTE Standards for Teachers, and the European DigCompEdu (Cabero et al., 2020).

The UNESCO ICT-CFT is specifically designed for both pre-service and in-service teacher training, providing policy guidance and capacity building in the evolving ICT sector. The framework has evolved over time, and its most recent iteration in 2018 integrates inclusive principles and addresses emerging technologies such as AI and the Internet of Things (UNESCO, 2018). The ICT-CFT structures skills into three levels: Knowledge Acquisition, Knowledge Deepening, and Knowledge Creation, each aligned to six dimensions of teaching. It serves as a comprehensive guide for teachers' professional development in ICT, helping them to improve teaching effectiveness and student outcomes.

7.3.3.2 Developing ICT Accessibility Capabilities

In accordance with Article 9 of the Convention on the Rights of Persons with Disabilities, states parties must take appropriate measures to encourage inclusive use and access to information, communications, and technology. In the literature, it has been shown that there is a considerable lack of ICT accessibility skills which has impeded the implementation of accessibility to digital products, contents, and services (Dare Index, 2020). In response, many organizations and educational and training institutions have managed to offer capacity building and training programs aligned with their own knowledge and understanding of ICT accessibility.

In light of this, Qatar Assistive Technology Mada Center has developed the Mada ICT Accessibility and Inclusive Design (ICT-AID) competency framework, as part of its fully fledged innovative Academy initiative towards fostering ICT accessibility proficiency in the region and beyond (Khribi et al., 2022). The framework describes all the relevant ICT accessibility competencies and capabilities required for students, teachers, and professionals to use and develop accessible products, contents, and services. It features six domains of competencies: (1) Becoming familiar with Disability and Accessibility; (2) Describing the legal landscape of Disability and Accessibility; (3) Making a sense of Universal Design; (4) Creating Accessible Digital Content; (5) Creating Accessible Web Content; (6) Making Digital Environments and Platforms Accessible.

Each of these competency domains covers a set of competencies that are further broken down into capabilities. These capabilities are required to apply, evaluate, and remediate digital accessibility in compliance with accessibility standards and best practices (Design, 2021a, 2021b). The framework can be adapted for use in different learning contexts and modes and can be used to develop, describe, and publish ICT-AID-aligned resources in courseware repositories. The Mada framework has been featured as an education standard on the Open Educational Resources (OER) Commons digital library and collaboration platform (Ben Brahim et al., 2018). This allows the framework to be used to index, align, and search OER, making it easier for learners and educators around the world to access and retrieve these resources. In summary, the Mada framework provides a comprehensive guide towards acquiring relevant competencies in ICT accessibility and fostering the integration of digital accessibility in education and training programs (Khribi et al., 2022).

7.3.3.3 Developing UDL Capabilities

Table 7.4 summarizes the various competencies essential for the successful implementation of UDL, such as understanding the needs of diverse learners, using differentiated instruction, using assistive technology, engaging in professional development, designing accessible training programs, collaborating effectively, and using interdisciplinary solutions. These competencies help to create more inclusive and accessible learning environments for all.

While UDL offers significant benefits, educators and designers may encounter challenges during the implementation process (Setiawan & Qamariah, 2023):

- Time and resources: Creating diverse learning materials and accommodating different learning preferences may require additional time and resources for educators and designers.
- Resistance to change: Implementing UDL may be met with resistance from educators accustomed to traditional teaching methods. Overcoming this resistance requires extensive professional development and support.
- Technology barriers: Integrating technology to support UDL can be challenging, particularly for institutions with limited access to digital resources and assistive technologies.
- Assessment methods: Designing assessments that align with UDL principles and accommodate diverse modes of expression, while ensuring fair and accurate assessment, can be challenging for educators.
- Professional development: Ongoing professional development for educators and designers is essential for successfully putting into practice of UDL. This training should include UDL principles, accessible technologies, and inclusive teaching strategies.
- Policy Support: Policies are needed that promote the adoption of UDL and provide resources and incentives for its implementation. UDL should be integrated into education policies to create a systemic approach to inclusive education.
- Research and evaluation: Research to evaluate the effectiveness of UDL and best practices is needed to inform instructional design. This evidence-based research will help to demonstrate the impact of UDL on learner outcomes.

In the meantime, we are all anticipating significant overhauls in our education systems, there are practical steps teachers can take right now to integrate UDL principles into their current teaching methods. For example, they can use free, accessible online resources, explore various media for instructional materials, adopt flexible assessment methods, participate in community-based resource sharing, initially educate themselves in UDL principles, and take advantage of technology advancements especially the promise of AI in education.

Indeed, the latter, particularly harnessing emerging technologies or Technology-Enhanced Design in Education (TDE) can add a bit of magic to engage educators with accessible learning tools and materials. The outcome could be a dynamic and comprehensive instruction framework that caters to the different needs of learners and provides them with the support they need to flourish.

Table 7.4 Competencies for teachers and learning designers (Meng, 2023)

Competencies	Description
Understanding Diverse Learner Needs	To cater to the diverse needs of students, including disabilities, cultural backgrounds, and language skills, educators should undergo specialized training and collaborate with experts. Tailored instructional strategies should be guided by ongoing classroom assessments and student feedback to effectively meet each student's unique learning profile (Lakkala & Kyrö-Ämmälä, 2021)
Differentiated Instruction	To help time-pressed teachers skillfully employ differentiated strategies (McLean, 2010), schools should offer focused, practical training and resources. This will enable educators to meet individual learner needs without adding undue complexity to their existing responsibilities
Assistive Technology Proficiency	Familiarize themselves with assistive technologies and accessibility tools to create an inclusive and accessible learning experience for all students (McLean, 2010)
Continuous Professional Development	Engage in continuous professional development to stay updated with best practices in inclusive education and UDL implementation. Stay abreast of the latest research and advancements to enhance teaching effectiveness (Indrawati & Octoria, 2016)
Accessible Training	Ensure that professional development opportunities are designed with accessibility in mind, allowing all educators to participate fully regardless of their abilities (Díaz-Maggioli, 2016)
Team Collaboration	Encourage collaboration among educators, special education teachers, support staff, and related professionals to leverage their expertise and effectively address diverse learner needs (Dieker & Murawski, 2013)
Interdisciplinary Solutions	Embrace interdisciplinary collaboration, involving experts from various fields, such as education, psychology, and speech therapy, to develop comprehensive and inclusive support for learners with complex needs (Brassler & Dettmers, 2017)

7.4 Technology-Enhanced Design in Education

Incorporating emerging technologies into educational design provides an opportunity to enhance accessibility and foster the implementation of UDL principles, ensuring universal access to education for all. By leveraging technology, educators can create inclusive and engaging learning environments that cater to the diverse needs and preferences of all learners (Pramesworo et al., 2023). This section explores key areas, along with relevant examples, where innovative digital tools and platforms, harnessing Artificial Intelligence AI, can support designers and educators in creating inclusive and accessible learning experiences in compliance with accessibility requirements and UDL principles, thereby accommodating diverse learning needs.

7.4.1 Technology and Education Design

In recent years, the integration of technology in education has profoundly transformed the education landscape, offering unprecedented opportunities to create engaging and personalized learning environments. In the realm of learning design, technology empowers learning designers and educators in several ways in a bid to effectively create engaging learning experiences. Indeed, designers now have a wealth of valuable educational tools and resources at their fingertips that can be used and integrated into the learning design process. In the following section, we briefly explore some key areas, along with examples, where digital tools and platforms are commonly used by learning designers (Khribi et al., 2015).

To collect data from learners during the analysis phase, survey and interview tools can be used to create questionnaires that collect demographic information and learners' needs and objectives, as well getting insightful feedback on learning experiences (e.g. SurveyMonkey, Google Forms, or Microsoft Forms). Additionally, flowcharts and mind maps are helpful for organizing and structuring information visually. Indeed, flowcharts provide a clear visualization of the sequential steps involved in a learning experience, which facilitates comprehension of the flow and identification of potential areas for improvement. This, in turn, would improve understanding of learner demographics, needs, and experiences.

To help with the design phase, visual wireframing, storyboarding, and mock-up tools are used to depict the content structure, types, formats, delivery, and assessment strategies. Storyboard and Microsoft PowerPoint are commonly used for crafting storyboards. Meanwhile, Figma, Adobe XD, and InVision are mock-up tools that not only support collaborative design, but also interactive prototyping.

During the development phase, online repositories and platforms hosting existing teaching and learning content and materials can help create instructional content. For example, learning designers can avail open educational resources (OERs) repositories and directories to locate and reuse high-quality content that has been created and shared openly by others (such as OER Commons digital library, MIT open courseware, MERLOT, and Wikiversity, etc.). Additionally, authoring tools and software can be used to produce and edit materials. Some popular authoring tools include Articulate Storyline, Rise, Adobe Suite, PowerPoint, Adobe Captivate, and Office Suite, as well as editing tools included by default in LCMS platforms such as MOODLE. Furthermore, various multimedia elements like Audio, video, graphics, gamification, and animation or simulation tools can also be used to add multimedia and enrich learning content making it more attractive and interactive. For example, learning designers can use video editing software to edit educational videos (e.g. camtasia), as well as animation software (e.g. Adobe Captivate and GoAnimate), and also H5P—Plugins in Moodle platform to create interactive content. Additionally, gamification tools, such as Classcraft, Kahoot, and Unity, can be employed to develop interactive and immersive learning games (Gemade, 2022). On the other, learning designers also use learning and/or content management systems LMS/LCMS to create and entirely manage online courses, as well as to track learner progress and get their feedback. Some popular online learning platforms include Moodle, Blackboard, Edmodo, and Canvas. Communication and collaboration tools whether synchronous and/or asynchronous (e.g. email, forums, wikis, blogs, chat, video conferencing, etc.) are valuable for interacting with learners and enabling their engagement and participation. These tools are invaluable for providing learners with support and guidance, as well as for fostering collaboration and discussion among learners. Video conferencing platforms enable real-time video meetings and discussions, enhancing learner engagement (e.g. Zoom, Microsoft Teams, Jitsi Meet, and Google Meet). Similarly, cloud-based office suites allow collaborative document editing through any device, promoting teamwork and shared contributions (Bakonyi et al., 2022). Furthermore, to gather and analyse learner feedback in a bid to improve learning experiences, tools like tracking, feedback, surveys, quizzes, polls, reviews, reporting, dashboards, sentiment analysis, and data analysis can be used (e.g. Quizizz, Socrative, EdPuzzle, Poll Everywhere, SurveyMonkey, Google, Microsoft Forms, etc.). Sentiment and data analysis are tools that greatly enhance the learning process. They provide educators with insights into student engagement, emotions, and performance. This enables them to assess the degree of student engagement, identify any challenges they may be facing, analyse their feedback, and identify areas for improvement (Banihashem et al., 2022). It is worth noting that learning management systems, like Canvas and Blackboard often come equipped with built-in analytics dashboards. In the same way, Moodle platform features a range of built-in analytics tools, as well as open-source reporting and dashboard plugins that offer insights for educators (Dondorf, 2022). In the same vein, learning designers can avail a variety of cloud-based management and collaboration tools to work on projects involving all stakeholders participating in the learning design process (project management, video conferencing, online collaboration tools, follow-up, etc.). As such, learning designers' tasks becomes more straightforward, and their time is saved allowing them focusing more on strategic and creative works.

When it comes to designing learning experiences in compliance with accessibility and inclusivity requirements, learning designers need to embrace the full potential of innovative digital tools and platforms that cater to diverse learning needs. Indeed, educators and learning designers are called to bridge educational gaps, ensuring that every student, regardless of their abilities or learning styles, has equal access to quality education. Accordingly, education materials should be designed and delivered in compliance with the principles of accessibility and universal design. On this premise, learning designers must ensure that digital education content is accessible to all students according to accessibility guidelines and standards. To this end, they need to add proper heading structures, alternative text descriptions, captioning and transcripts to videos, and text-to-speech options, benefiting thus students using screen readers or other assistive technologies. Additionally, possibilities for adjustments through specific features available in accessibility toolbars can be added like font size and style, colour, zoom functionality, keyboard navigation, background colours, etc. Content authors and learning designers can use accessibility checkers and validators to ensure the compliance of the digital content to accessibility requirements (*Web*

Content Accessibility Guidelines (WCAG) 2.1, 2023), such as tools to check document accessibility (e.g. built-in accessibility checkers in office suites, Adobe Acrobat Pro Accessibility Checker, etc.), Web accessibility (e.g. WAVE—Web Accessibility Evaluation Tool, Axe Accessibility Checker, etc.), colour Contrast (e.g. contrast checker, colour contrast analyser, etc.) (Web Accessibility Evaluation Tools List, 2020). By utilizing such tools, educators and learning designers can take proactive steps to build accessible resources that meet the different requirements of learners, including those with impairments.

7.4.2 AI-Powered Learning Design

With the rapid adoption of Artificial Intelligence in education, particularly the current hype of generative AI, many transforming possibilities are being created to enhance the learning design process, resulting in more individualized and effective learning experiences (UNESCO, 2023). Indeed, by enhancing each phase of the learning design process, AI-powered tools have the potential to empower learning designers in creating efficiently and sharply engaging learning experiences. In the following, we shed light through relevant examples of how AI can enhance each phase of the learning design process.

To help during the analysis phase, AI-powered tools can assist in conducting learning needs analysis, identifying learner characteristics and context, and expressing learning objectives. The substantial amount of data collected from learners whether implicitly or explicitly is thoroughly analysed to discern patterns and trends. Indeed, learning analytics platforms powered by AI can process students' historical data to identify learner characteristics, learning gaps, and areas where students struggle the most (Martinez-Maldonado et al., 2022). Through the application of machine learning algorithms, profiles and models of learners are built and used to provide personalized instructional content accordingly. Some notable examples of AI-powered tools and platforms gathering and analysing data, as well as providing reporting, visualizations, and insights, and enabling educators to identify student needs and assess the effectiveness of learning experiences, include Google Forms with Google AI and SurveyMonkey with AI-driven analytics. In the same way, Moodle learning analytics features can be used to track learner progress, identify areas where learners are struggling, and provide personalized feedback. Intelliboard and Learnerscript are learning analytics platforms that collect and analyse data from various sources, including LMSs, student information systems (SISs), and assessment tools, offering valuable insights into learner progress, engagement, performance, and personalized content delivery, etc. (Dondorf, 2022).

AI can enhance the design phase by using algorithms to analyse data and provide recommendations for creating effective learning experiences (Dogan et al., 2023). This encompasses generating ideas for activities that align with learning objectives. Furthermore, AI can be used to create prototypes of learning experiences, such as simulations and virtual reality which can be tested with learners for feedback before development. Moreover, AI can be used to analyse learner engagement and performance data in order to identify areas where improvements can be made (Ben Daamech & Khribi, 2019).

During the development phase, AI can be used to automate content creation making it faster, efficient, and scalable. Recently, generative AI tools have become widely used to generate learning content based on templates and asset libraries, that can be easily customized according to different contexts and target audiences. More specifically, generative AI can be used to create syllabus, outlines, learning objectives, content, and assessments (Alasadi & Baiz, 2023). In this process, it is significant to note that platforms such as ChatGPT and Google Bard have been invaluable in giving teachers creative ways to enhance their instructional resources, as Fig. 7.5 illustrates.

Furthermore, the delivery of learning materials can be adapted using AI to meet individual learner needs and preferences. This includes suggesting learning paths, suitable materials, feedback, etc. (Murtaza et al., 2022).

During the evaluation phase (Ouyang et al., 2022), AI helps, e.g. in the analysis of learner usage data and the delivery of performance and progress comments. Accordingly, areas of strength and weakness can be identified and used to create improvement goals.

It goes without saying that AI is attracting significant interest for its great potential to revolutionize learning design. In the area of teacher-focused applications, AI offers capabilities such as plagiarism detection, intelligent curation of learning materials, and classroom monitoring. These automated functions have the potential to free up educators and learning designers to focus on creative and strategic tasks.

Nevertheless, it is important to maintain objectivity and avoid overestimating the extent to which AI can replace human decision-making and expertise, especially in education. We should not lose sight of the fact that AI's potential raises ethical issues regarding data privacy and the possibility of educational disparities. Although AI can support in a variety of learning design tasks, it cannot replace the crucial aspect of quality humans in preparing and delivering materials. As we navigate the growing presence of AI in learning design, it is essential to balance its innovative capabilities with ethical and pedagogical considerations.

7.4.3 Artificial Intelligence and Digital Accessibility

Ensuring the accessibility of educational materials is crucial for creating inclusive and accessible learning experiences. AI-powered tools can significantly support learning designers in evaluating digital content to identify accessibility issues and potentially suggest remediations, ensuring compliance with accessibility standards and guidelines such as the Web Content Accessibility Guidelines (WCAG) (Mrayhi et al., 2023). Web accessibility evaluation tools work to provide AI-based automation testing and fixes, generally combined with manual audits. These tools scan and analyse meticulously the content to spot accessibility issues, then provide detailed

Default (GPT-3.5)

Course Title: Re-Imagine Future Education

Course Description: Explore innovative approaches to reimagining education, focusing on improving accessibility through sensor detectors and machine learning.

Week 1: Rethinking Education

Day 1: The Evolution of Education

Day 2: Challenges and Opportunities in Education

Day 3: Group Discussion on Current Education Landscape

Week 2: Technology and Accessibility

Day 4: The Role of Technology in Education

Day 5: Sensor Detectors and Accessibility

Day 6: Case Studies on Technology in Education

Week 3: Inclusive Education

Day 7: Universal Design for Learning (UDL)

Day 8: Ethical Considerations in Education Technology

Day 9: Designing Inclusive Educational Experiences

Assessment:

- Participation and Engagement: 20%
- Assignments: 40%
- Final Project: 40%

Fig. 7.5 How to use ChatGPT to create a personalized syllabus

reports essential for remediation strategies (e.g. AudioEye (Mancilla & Frey, 2023), Axe Accessibility Engine (Ismail & Kuppusamy, 2022), Deque (Pionke & Schroeder, 2020)).

Other tools rely on AI capabilities to simplify and enhance the clarity of complex textual content, thereby improving readability, for example, for students with learning difficulties and cognitive disabilities (Rodrigues, 2023). AI is used to analyse text, identify complex sentences and passages, and then rewrite it simpler and concise while retaining the original meaning (e.g. IBM Watson Content Clarifier).

Additionally, there is an increasing number of AI-based platforms that are used to generate text descriptions from images and videos (automatic conversion from image and video to text) which can help adding textual descriptions to images and captions to videos, making therefore multimedia content accessible to people with visual and hearing impairments (e.g. SPEAKAI converts video to text, veed.io offers a variety of tools for transcribing, subtitling, and translating videos, Seeing AI (Microsoft) offers audio descriptions of visual elements for visually impaired, Rewordify simplifies complex text for improved comprehension, Ava offers real-time captions for deaf and hard-of-hearing students, Otter.ai generates real-time transcriptions for lectures and conversations, etc.).

With that being said, a holistic approach to accessibility remains essential as educators should not rely solely on AI when designing for accessibility. They still need for instance to use content authoring tools to create and edit appropriate alternative texts and descriptions, and make sure that the content they offer is fully accessible for all, including students with disabilities.

7.5 Artificial Intelligence and UDL

Artificial Intelligence has also the potential to enable educators and learning designers fostering the implementation of Universal Design for Learning (UDL) to provide inclusive learning experiences meeting diverse learner needs. The integration of Artificial Intelligence in education has opened new avenues for learning designers to adhere to UDL principles effectively. Indeed, AI can offer innovative solutions to cater to the variability of learners, ensuring that educational content fits everyone's needs and expectations, regardless of different abilities or learning preferences. In the following, we explore briefly relevant areas where AI can support the implementation of UDL principles, namely, Representation, Engagement, and Action and Expression (Bray et al., 2023).

To help providing multiple means of representation, AI can be used to generate automatically and swiftly alternative representations of the content. Text-to-speech conversion can be used to generate audio versions of textual materials. For example, Bookshare, the well-known accessible online library, uses AI to provide text-to-speech capabilities, allowing students, in particular, those with print reading disabilities, to listen to educational materials, textbooks, and literature instead. Text to image and image to text automatic conversion can be used to provide both texts and images offering educator's additional options to provide different formats of the same content. Likewise, for video to text and text to video automatic conversion. Machine translation can also be used to translate automatically written and spoken language into different languages. This can help making the educational content available in different languages, supporting thus students who have language barriers.

To provide multiple means of engagement, AI can be used to ensure learning personalization according to learner needs and objectives. Some relevant examples include providing personalized learning paths (Zhang et al., 2023), adaptive feedback, course recommendation (Khribi et al., 2009), intelligent tutoring systems (Wang et al., 2023), conversational chatbots (Kurni et al., 2023). Khanmigo (2023), e.g. the Khan Academy chatbot, can act as an AI-powered teaching assistant for students, and can also be used to empower teachers in planning lessons and getting insightful student feedback. Furthermore. virtual reality simulations can be used to create immersive and interactive learning experiences. AI can help, e.g. in inferring student attention and involvement from their gestures and eye movements. It enhances extended reality (XR) and enables more natural and intuitive interactions by detecting and analysing student behaviour and preferences in real time (Alkaeed et al., 2023).

As for the third UDL principle, it calls to provide multiple means of action and expression so that students can demonstrate their understanding in diverse ways. AI solutions offering automatic conversion from one format to another (e.g. text, image, diagrams, charts, video, audio, etc.) can help incorporating multiple formats for demonstrating knowledge. AI can also be used to generate a variety of assessment formats, including adaptive quizzes, essay questions, project-based assessments, real-time self-assessment, instantaneous feedback, etc.

It is worth noting that several factors need to be considered when it comes to avail AI potential in a bid to enhance inclusivity and accessibility in learning design, to name but a few: technology limitations, effectiveness, costs, ethics, data privacy, teacher and student required competencies, the risk of over-reliance, etc. It is thus important to conduct rigorous studies to assess all these aspects and manage the risks and threats associated with AI. Ultimately, it is imperative for educators to acquire all relevant AI competencies to promote the responsible, ethical, equitable, and inclusive design and use of AI in education (*UNESCO's ICT Competency Framework for Teachers | UNESCO*, 2023).

7.6 Conclusion

The rapid evolution of technology and the changing landscape of education demand a transformative approach to design future education for all. As educators, learning designers, and researchers, we stand at the nexus of an educational revolution where inclusivity and accessibility are not merely aspirations but imperative foundations upon which the future of education must be built. The voyage towards designing future education for all dictates a holistic understanding of the diverse needs of learners and a commitment to nurturing an environment where every individual, regardless of their background, abilities, or circumstances, can thrive and reach their full potential.

In this chapter, we have delved into the principles and frameworks of education design shedding light on how continuous professional development and lifelong learning play a role, for educators and learning designers in the areas of ICT, UDL, digital accessibility, and AI. It highlights the need for integration of technology. Emphasizes that accessibility should be a fundamental aspect of the design process rather than an afterthought. Additionally, it recognizes the importance of learning experiences to put up the range of individual characteristics present, among learners. By embracing the principles of universal design for learning, educators can create inclusive and accessible learning environments, accommodating the varied learning preferences, needs, and abilities of all students.

Furthermore, our discussion has underscored the potential of innovative technologies and Artificial Intelligence in empowering educators and learning designers and fostering inclusivity. These emerging technologies, when ethically and thoughtfully integrated, have the power to revolutionize the educational landscape by providing tailored support to students with diverse needs, thereby promoting equitable access and opportunities.

As we move ahead it's important to acknowledge that the ongoing effort to design education for everyone using emerging technologies requires collaboration, from stakeholders. This includes policymakers, educators, parents, and technology developers who must work together to bridge the divide and ensure that every learner is included. Additionally, it necessitates a commitment to research and development encouraging the exploration of methodologies and technologies that can improve inclusivity and accessibility, in learning experiences.

By embracing the principles and frameworks conferred in this chapter we can lay the foundation for a future where education becomes a source of empowerment, enlightenment, and equality for all.

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Chapter 8
From Principles to Questions: Hybrid Active Learning in Art and Design Practices

Amic G. Ho

Abstract Digital literature provides a platform for flexible experimentation in narrative information construction. Computer-literate authors produce more engaging works, experiment with novel narrative methods, and connect with larger audiences via digital media as compared with traditional media. Because digital literature necessitates the creation of original and practical ideas, products, and solutions, creativity is a crucial aspect of this form of writing. Interactivity and the capacity to incorporate audio and visual components distinguish digital writing. Digital literature integrates interactive and immersive media, such as hypertext, illustrations, and video, to enhance the reading experience. Augmented reality may be incorporated into digital writing, which allows users to interact with virtual objects in the real world. Because it can be viewed from anywhere, digital literature is a potent instrument for the global dissemination of ideas and the advancement of social and intellectual interaction. The combined active learning option is suggested to improve learning outcomes in art and design training. Blended learning offers students the best of both realms by combining traditional classroom instruction with digital resources. This chapter examines the advantages of mixed active learning for disciplines such as art and design education that place a premium on experiential and collaborative learning. Active learning strategies would enhance students' ability to interact with course materials in various environments. Learning outcomes in diverse contexts are assessed using teaching methods such as class participation, group assignments, and online profiles.

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8.1 Introduction

In recent years, there has been a rise in interest in hybrid active learning, a teaching strategy that mixes online and face-to-face learning techniques. This strategy enables students to engage in realistic learning experiences and investigate real-world challenges through online and in-person interactions. Unlike conventional lecture-based teaching approaches, active learning emphasises student engagement in meaningful individual or group activities that demand critical thinking, reflection, and cooperation. Art and design education is a discipline that mainly focuses on interactive learning and hands-on experiences. Incorporating active learning ideas into hybrid settings might thus give students additional opportunities to interact with course material and enhance their abilities. To enhance active learning in art and design education, teachers may construct hybrid courses that incorporate in-person and online components, such as breakout rooms, virtual critiques, and digital portfolios.

In addition, it is crucial to evaluate the length of learning sessions and the significance of taking frequent breaks to improve learning results. According to studies, students need five to ten minutes of breaks for every 30–60 min of studying, with the length of the learning session dictating the length of the break. In addition, assessment is an essential component of any course and, in hybrid contexts, it is critical to construct exams that evaluate both online and in-person learning outcomes. In hybrid active learning settings, evaluation techniques such as class participation, collaborative projects, and digital portfolios may be used to evaluate students' learning results. Therefore, hybrid active learning provides a potential prospect for art and design education, as it enables students to participate in hands-on activities, interact with peers, and investigate real-world challenges in both online and face-to-face settings. In hybrid active learning settings, including active learning concepts, implementing effective evaluations, and addressing the length of learning sessions and the need for frequent breaks may improve learning results (Qu et al., 2021).

8.2 Digital Literature

The term 'digital literature' refers to literary works that are generated and delivered digitally, often combining multimedia components such as audio, video, and interactive aspects. This kind of literature may be accessed by a variety of digital devices (including computers, mobile phones, and tablets) and its popularity has grown in recent years.

Digital technologies have altered the production, distribution, and consumption of literature, blurring the lines between conventional literary genres and other creative media. Interactivity is one of the primary qualities of digital literature. Digital literature—as opposed to conventional literature, which is a static medium—enables the reader to interact with the text and become an active participant in the tale (Liu, 2022). This may contain interactive elements, such as hyperlinks, animations, and videos, which give context and improve the reading experience. The potential of digital literature to add multimedia components is another crucial factor. Digital literature may combine music, sound effects, and even video to enhance the reader's immersion and engagement. This may incorporate interactive elements such as augmented reality (AR), which enables the reader to interact with digital items in the actual world (Ni & Zhang, 2022). Traditional literature has the capacity to reach a larger audience than digital writing. Since it is digitally published, it is accessible from anywhere in the world and is readily shareable and distributable through social media and other digital channels. This makes it an effective instrument for propagating ideas and fostering cultural interchange.

Digital literature is an intriguing new frontier for the literary world as a whole. Its capacity to include multimedia elements and interactivity expands the narrative options and provides a more interesting and immersive experience for the reader. As technology continues to advance, it will be fascinating to see how digital literature adapts. The writing of reviews provides unique opportunities for experimentation and innovation, enabling writers to explore new kinds of narrative and communicate with their readers in novel ways. Digital literacy provides the basis for other qualities such as creative thinking, critical thinking, learning to learn, communication, teamwork, and social responsibility. By acquiring digital literacy skills, writers may utilise digital technology to produce interactive and multimedia-rich works, experiment with other types of narration, and reach larger audiences through digital platforms. Creativity is another significant topic associated with digital literature. The act of developing innovative and useful ideas, products, or solutions is creativity. In digital literature, creativity entails the use of digital resources to develop new narrative forms, such as interactive fiction, hypertext, multimedia, and transmedia storytelling. Using these technologies, writers may ingeniously communicate with their audiences and create immersive and captivating novels.

In addition to creativity, 'ideation' is another term associated with digital literature. Ideation is the process of producing ideas and solutions through methods like brainstorming, prototyping, and eliminating the worst. Ideation is an essential phase in the creation of digital literature since it enables writers to conceive and improve concepts for their digital compositions. In addition, idea abstraction is equally applicable to digital literature. Conceptual abstraction is the process of discovering universal, abstract, and timeless concepts in literary works. In digital literature, writers may employ abstraction to construct intricate and meaningful tales that explore topics and ideas relevant to a broad audience. Therefore, digital literature provides unique chances for experimentation and innovation, enabling writers to explore new kinds of narrative and engage readers in novel ways. To attain these objectives, writers must acquire digital literacy skills, be creative, participate in brainstorming, and form abstract concepts. By adopting these notions, writers may produce immersive and compelling digital texts that stretch the bounds of conventional narrative.

Nonetheless, it creates issues in terms of preservation, accessibility, and authenticity. Digital literature refers to the creation and distribution of literary works in digital media, such as e-books, online articles, and interactive fiction. The discipline of digital literature offers new opportunities for creative expression and audience involvement as digital technologies continue to develop. However, digital literature also presents a number of preservation, accessibility, and authenticity-related issues. Data loss is one of the greatest obstacles to digital literature preservation. Digital texts, unlike physical books, may quickly become corrupted or lost if not properly saved and backed up. This is especially troublesome for exclusively digital works, for which there may be no physical copies to fall back on in the event of data loss. Digital storage devices may become obsolete with time, making it harder to retrieve old works saved on outmoded formats. Maintaining access to digital books also raises several obstacles. As software and hardware methods used to access digital files may become outdated or incompatible over time, the file format may be a significant barrier to accessing digital works. Inadequate financing for digital preservation activities may also result in the loss or inaccessibility of works owing to technical obsolescence. In addition, establishing the authenticity of digital literature might be difficult. Digital writings, unlike physical books, may be readily changed or altered, raising doubts about their validity and integrity. This is especially troublesome for purely digitally published works, since there may be no physical copies accessible to validate the original material. Despite these obstacles, the area of digital literature continues to provide fresh opportunities for creative expression and audience involvement. For instance, digital literature may include multimedia components, such as audio and video, which enable new kinds of narrative and interaction.

8.3 The Influence of Digitalisation in Art and Design Education

In recent years, the impact of digitalisation on art and design education has been substantial. Digital technology has altered how artists develop and exhibit their work and created new avenues for creative expression and audience connection (Wang, 2021). Some significant discoveries from the online search results on this topic are offered. The Ministry of Culture has undertaken the digitisation of cultural assets, demonstrating an understanding of the significance of digitalisation in conserving and promoting art and culture. It is pertinent to study the effects of this notion on the effectiveness of hybrid active learning in art and design education since digitalisation is a fundamental part of contemporary education that may improve student-learning outcomes. Digitalisation is the process of converting physical items, such as art and historical relics, into a digital format and hence making them more accessible and shareable to a larger audience than before.

The digitisation of cultural objects may provide students with a wide range of art and design resources for use in art and design teaching. Students can participate in projects that mix digital and traditional art and design methods, such as the creation of digital artworks and the study of digitalised cultural artefacts, through hybrid active learning. The ability to think imaginatively and analytically and to problem-solve is important in the art and design industries, and this technique may help students build these skills. Furthermore, the integration of technology in art and design classes corresponds to the tendency in higher education towards the use of active learning techniques. 'Active learning' is a phrase used in education to describe instructional techniques that promote pupil involvement beyond simply taking notes. It has been demonstrated that incorporating active learning tasks, such as the use of digital resources and tools, improves a student's scholastic success and attitude. It may help students improve their understanding of art and design ideas and skills, both of which are important for their career growth.

The Ministry of Culture's endeavour to digitise cultural assets highlights the significance of incorporating technology in the realm of art and design education (Disatapundhu & Phuttitarnhu, 2012). Active hybrid learning enables students to engage in activities that blend traditional drawing and design techniques with digital resources and tools. In the art and design industries, the possession of imaginative and analytical thinking skills as well as problem-solving abilities is deemed crucial. Such a cognitive approach may prove advantageous in these domains. The development of digital literacy serves as a fundamental foundation for the cultivation of critical thinking, problem-solving skills, self-directed learning, effective communication, collaborative problem-solving, and social responsibility. Proficiency in digital technology is necessary to effectively utilise the ever-present digital devices in our daily routines. Individuals who are digitally literate can investigate and use digital tools to communicate their creative thinking, which includes investigating ideas, creating new material, and innovating. People can use technology to improve their creative-thinking skills by learning how to use digital devices effectively, whether they are making images, composing music, or writing blog articles (Ni & Zhang, 2022). Furthermore, digital literacy provides access to online tools and organisations that foster innovation and provide motivation.

To develop critical thinking skills, especially concerning evaluating and comprehending digital material, digital literacy is essential. The abundance of online material makes it all the more important to evaluate online resources' accuracy, completeness, and credibility. The ability to recognise reliable sources and avoid falling for hoaxes is an important life skill that can be fostered through exposure to digital media. Nowadays, in an ever-evolving digital world, the ability to read, write, and use the internet proficiently is crucial. The ability to use and assess online resources for educational purposes and the flexibility to learn and use new technologies, platforms, and tools are hallmarks of a technologically competent individual. Educators can better use the online resources available if their students have mastered digital literacy.

Communicating one's thoughts and emotions through various online mediums is increasingly valued in today's information-based culture. Some familiarity with digital technology is required to effectively use digital communication tools, such as email, instant messaging, video conferencing, and social networking. Those who are more technically adept will be able to tailor their messages to the specifics of the digital networks they employ. A person's ability to communicate and work with others using various digital devices depends on their level of digital proficiency. A person's ability to join online conversations, share files, and collaborate on projects depends on their digital literacy level. Another facet of digital literacy is knowing and following the protocols of online communities. Given the pervasive nature of digital tools, we must acquire the knowledge and understanding to employ them responsibly and ethically. Learning to think about the ethical, legal, and social ramifications of online actions is essential to becoming digitally literate. This involves adhering to copyright and licencing regulations. The ability to tailor one's education to one's own needs and interests has been made feasible by digitalisation, which has revolutionised the delivery of art and design courses in higher education.

Hybrid active learning is a method of education that combines online and classroom-based learning. There is evidence that this method raises student interest and performance. Hybrid active learning has the potential to provide art and design students access to more individualised and adaptable classroom environments. Digitalisation in art and design programmes may be traced back to the increasing use of digital tools in the creative industries. Personalised and adaptable learning is now possible because of the proliferation of digital technologies and platforms used in higher education, which has revolutionised the delivery of art and design courses. Due to the widespread availability and convenience of digital resources, students may now study and complete tasks whenever it is convenient for them.

In addition, digital technology has allowed for the creation of novel strategies for instructing students in the visual arts and design (Li et al., 2022). Students may now engage in group projects and share their progress with teachers and classmates using online collaboration tools and platforms. In addition, the incorporation of new modes of evaluation, such as online portfolios and multimedia projects, has become feasible due to the use of digital technology; these modes of evaluation more accurately represent the complex and diverse talents necessary in the domains of art and design. As a whole, the introduction of digital tools into art and design classrooms has expanded students' options for individualised study and teaching. Making use of these possibilities and increasing students' interest and success in art and design classes may be facilitated via the hybrid active learning method, which combines conventional face-to-face instruction with online learning.

Digital technology has had a substantial impact on painting and drawing, providing artists with new avenues of expression and engagement. Painting and drawing have been substantially influenced by technology, which has created new opportunities for individual expression and community involvement. Digital technology has expanded the scope of traditional art forms by providing an abundance of new tools and techniques to creators.

The proliferation of digital technologies has provided visual innovators with a wealth of resources to commence their work. Digital tools, layers, and effects in programmes such as Adobe Photoshop, Illustrator, and Corel Painter allow artists to replicate the look of traditional media such as oils, acrylics, and watercolours. Due to the programme's layering and effects capabilities, artists can experiment with new ideas or make fast alterations with no concern for damaging their work.

The evolution of digital technology in the form of graphical devices and styluses has also facilitated the intuitive and user-friendly creation of digital art (Li et al., 2022). The artist's hand movements are translated into digital lines, simulating the experience of drawing or sketching on paper. This innovation has facilitated the transition of traditional artists to digital art and piqued the interest of those who have never drawn or doodled before and are attempting to acquire large sums of cash. Posting artwork to a social networking site, a personal website, or an online store allows artists to reach a global audience regardless of time zones or distance. This type of spotlight has made it possible for emerging artists to exhibit their work to a wider audience than before and has created new opportunities for mutual support in the form of collaboration, constructive criticism, and professional networking.

Additionally, the development of digital technology has led to the emergence of novel, inventive techniques, and approaches. More than ever, artists can now freely experiment with mixed media, fusing traditional and digital techniques to create genuinely unique works. As traditional and digital art practices converge, digital sketching, concept art, and pixel art have emerged as new art forms. Digital tools have revolutionised the painting and drawing processes. They have facilitated the development of novel creative production techniques, the exploration of untried modes of expression, and the establishment of a global audience. With the aid of both traditional and digital media, artists have broadened the scope of their work and altered the very essence of drawing and doodling.

Technology, art, and people are increasingly intersecting, and artificial intelligence (AI) has facilitated impromptu participation in the process of artistic creation (Chen, 2018). There are now more inventive options as a result of this. In this example, the confluence is visible. In particular, AI is the main driver behind the growing interdependence between technology, art, and humanity (Tao, 2022). It is becoming harder and harder to end this marriage. The creation of new works and the reception of those works by viewers are just two of the many facets of the arts that AI has the potential to change. Members of the artistic scene may benefit greatly from this growth. Thanks to the tools and technologies driven by AI, artists now have access to new means of expression and can push the limits of their creativity in new ways. Systems with AI can examine and glean knowledge from already-created pieces of art (Xiang, 2023). By rearranging and revising components drawn from a broad variety of sources, these systems can then proceed to create new concepts and techniques. Innovative fusions of various styles, processes, and ideas are now possible as a result, which was previously unthinkable when using more traditional methods of production. The methods of contact between creatives and the ways in which they assess their work are currently changing as a direct result of the growth of AI (Ruiz-Arellano et al., 2022). Giving creatives input on their efforts is one way to achieve this. When using this method of cooperation, artists and AI can converse with one another in both directions. This discussion might result in the creation of original, surprising pieces of art that illustrate the interaction between human ingenuity and AI's cerebral capacity.

A new age of inclusive and interactive art encounters was also brought in by the creation of AI. Artworks were presented to audiences in novel and exciting ways during this period, ushering in a new age for the art world. AI has the potential to allow statues and exhibits to alter and react in response to visitors' presence and the activities they engage in, giving each person a unique and intriguing experience. This form of active audience involvement enhances the connection that already exists between the audience and the work of art by erasing the barrier that has traditionally existed between the creator and the viewer. The development of AI also has the ability to broaden the range of people who can understand and participate in the creative process. Independent of the artist's prior experience or the context in which the idea was conceived, AI-powered platforms and tools have the potential to assist aspiring artists with learning and improving their skills. AI can also provide data-driven observations that artists and art organisations can use to make their events and displays more accessible and diverse. Artists and arts organisations are free to use these resources. Last, but not least, AI has been crucial in the development of fresh methods of inventive participation. This has resulted in a closer bond between technological advancement, original thought, and specific people than could previously be achieved. AI's potential to facilitate hitherto unimaginable forms of expression, collaboration, and interaction has the potential to completely remake the field of art.

Through social media and online conversations, digitalisation has allowed superb two-way communication between artists and their followers. With the rise of digital technology, the dialogue between artists and their followers has become more immediate and engaging. New digital tools, such as social networking and Skype, have made it simpler for creators and fans to communicate. Instagram, Twitter, and Facebook have evolved into virtual venues for artists to share their work with the world, promote upcoming events, and interact with fans. Artists can use these sites to share unfinished work, involve followers in the creative process, and solicit feedback. Because of the immediate response to an artist's work, followers may feel more connected to those they idolise. Live streaming and video conversations, for example, have made it easier for artists to interact with their followers. Artists can access a global audience in real time by hosting video events on Zoom, Skype, and YouTube Live. Lectures, Q&A sessions, and concerts are examples of such events. Internet shows can be a more intimate and exciting experience for everyone involved because there is no boundary between the audience and the performers.

Furthermore, technical developments have created new channels of communication between creatives and their customers. It is now feasible to integrate public input into the creative process, due to the development of online organisations and interactive media. This method strengthens the connection between artists and their fans by allowing them to add to the production. As a consequence of digitisation, there is now greater access to creative works. To name a few, YouTube, Vimeo, and SoundCloud provide artists with a global audience to share their work and engage with other art enthusiasts around the globe. Participation in the arts can be made more available, which increases participation and diversity. Social media and video messaging are just two examples of digital tools that artists and their fans can use to interact. As a consequence, artists and fans can now engage in more active forms of communication and reciprocal creative exchanges.

With automation bringing new possibilities for modification and personalisation, it affects the work of quality specialists, where investigations may use basic principles of quality management. As digitalisation allows new possibilities for customisation and tailoring, the effect of digitalisation on the work of trained professionals can be examined in light of the core principles of quality management. Because of quality management, a company's products and services are dependable, meet client standards, and are provided on time and within budget. Digitisation is called digitalisation when digital tools change business models, generate new revenue and value-creating opportunities, and simplify processes.

Personalisation and adaptation improvements are one way that technology has impacted quality management. Companies can better meet their clients' needs by gathering and assessing vast client data, the process being made feasible by modern digital technology. Quality management relies highly on customer satisfaction, which can be increased through modification and personalisation. Another way that technology has impacted quality management is through the outsourcing of mundane tasks. Automation can increase efficiency, reduce errors, and provide real-time data for monitoring and controlling operations. Quality assurance experts using real-time data to identify issues and promptly take corrective action may improve product or service quality. Because of automation, new methods and tools for measuring and improving quality have also been developed. Large datasets can be examined using sophisticated analytics and machine learning to disclose trends and direct quality-of-life decisions. As a result, rather than simply responding to issues, quality assurance specialists can foresee and avoid them.

Furthermore, digitalisation has changed quality management practices by encouraging greater interdepartmental collaboration and internal contact. Quality improvements can be accomplished by improving cooperation across teams and divisions through digital tools and platforms. As a result, the organisation may be better able to handle issues and make choices in a timely and effective manner. High-quality digital content has become increasingly important in this age of automation. Businesses must provide interesting, instructive material and customise it to their particular community to establish authority as industry experts and gain the trust of potential customers. Consequently, industries have shifted towards a more content-centric strategy for quality management.

Technology has changed the roles of quality assurance professionals. To effectively handle and improve quality in a digital world, quality practitioners must learn new skills as more companies adopt digital technology and processes. They must embrace new working methods, such as digital tools and collaboration and data analysis platforms. Overall, automation has significantly affected the quality management field, offering both challenges and opportunities. Using digital technology, quality specialists can boost efficiency, customisability, and customisation as well as internal collaboration and communication. As a consequence, consumer satisfaction and company outcomes may improve.

The quantity of time given to art and design courses varies greatly depending on the type of school. As a result, students with greater talent are being deterred from continuing a job in the field, which raises significant concerns about the value and usefulness of art and design education. Unfortunately, the search results must explicitly address how the type of school influences art and design teaching or why academy-sponsored schools dedicate less time to these topics. Teaching children about art and design is an excellent method to encourage them to 'think outside the box'. Students can express themselves, refine their problem-solving skills, and gain insight into other cultures and eras by studying various artistic techniques. Furthermore, students can think about technology's effect on how work is produced, shared, and experienced.

Environmental awareness and responsible conduct when managing and sharing resources are two other advantages of art and design schooling. Furthermore, children learn the importance of minimising environmental impact by properly preserving, caring for, and tidying up craft materials. The findings suggest that, despite the importance of such education, certain types of institutions may need to reduce the amount of time allotted to art and design teaching. This could be due to budgetary constraints, a preference for other classes deemed more critical, or other problems not covered in the search findings. As a result, concerns about the worth and usefulness of art and design teaching in schools emerge and talented young people may be discouraged from following their talents in these areas. Schools, instructors, and lawmakers must value art and design education because of its benefits for students and society. By promoting creativity, critical thinking, and cultural knowledge, arts and design education helps students become well-rounded individuals who can better manage the difficulties of today's society. Although the provided web search findings do not directly address the impact of school type on art and design education, it is clear that art and design education plays an essential role in students' general growth. Schools and instructors must give children ample opportunities to exhibit their ingenuity and acquire critical twenty-first-century skills through art and design courses.

Authors of a study on this topic offer recommendations for how to adjust the curriculum of art and design programmes in higher education institutions so that students can keep up with the most innovative design trends of the digital age (Bala, 2010). Business model transformation, process simplification, and the development of new avenues for generating money and value are all examples of what we mean when we talk about 'digitalising'. This process entails changing data from analogue to digital form so that it may be stored and retrieved digitally. The advent of digital technology has the potential to completely alter many markets, including the creative one.

The introduction of new digital tools, technology, and dissemination methods for creative expression has the potential to have far-reaching implications for the subject of traditional art design. To thrive in the new digital economy, artists may need to refresh their knowledge and skills (Vaz et al., 2021). Teachers should reconsider their art and design education methods to better prepare students for the opportunities and challenges of the digital age. By incorporating digital tools and software into the learning process, they can help students acquire the knowledge and skills required to create digital art and design projects. Students may be instructed in this field using tools such as 3D designing and printing and enhanced virtual reality (VR) technology. To promote cross-disciplinary study and in order to thrive in the digital age, students of art and design may profit from knowing computer science, engineering, and data processing. Interdisciplinary classes and group projects at colleges and institutions can help students understand the digital environment and its impacts on artistic disciplines. As the use of digital networks for the exhibition and sharing of artistic works becomes more common, students should be taught how to cooperate and converse effectively online. To this end, courses should stress the use of digital tools such as social media, web profiles, and marketing techniques. A curious and exploratory mentality should be encouraged by giving artists the tools to attempt something new in this digital world. Teachers can provide their students with a skill set to serve them well in future employment by pushing them to experiment with new digital tools and technology. As a result, new art and design education methods are required, since the digital age promises to radically modify traditional art and design practices. Adopting digital technology, enabling multidisciplinary learning, promoting online teamwork, and encouraging innovation can help colleges and institutions better prepare their students for success in today's information age. Overall, digitalisation has had a significant effect on art and design courses, offering new paths for artistic expression and involvement while also posing accessibility and legitimacy challenges. If art and design education is to successfully educate the inventive minds of the future, it will need to alter in reaction to the fast growth of digital technology.

8.4 The Trend of Art and Design Education

Technological developments, pedagogical theory, and shifts in public opinion have shaped the evolution of art and design curricula. The rise of digital resources in the art and design classroom and the significance of interdisciplinary methods will now be investigated. Over the last few decades, there has been a dramatic drop in the proportion of pupils receiving artistic instruction. This shift is mainly attributable to the proliferation of standardised test-based classes and initiatives like the EBacc, which have led to fewer elective options in the arts. A multidisciplinary strategy has been required to educate artists and designers to be effective in various cultural situations and employ their abilities in various educational settings, such as schools, institutions, and community organisations. This approach, which encourages collaboration and cross-disciplinary study, improves students' learning and skill development. Technology permeates today's society, and art and design courses have recognised its potential to enhance teaching. As e-learning and digital networks gained prominence, they gave students new opportunities to engage with expert artists and creators. Science, technology, engineering, art, and math (STEAM) programmes have evolved as a consequence of integrating technology into the art classroom to promote creativity, critical thinking, and problem-solving through exposure to the arts and STEM fields.

In recent years, critical studies and cultural influence have become more prominent in art and design courses. Critical studies examine the societal roots and outcomes of innovation and the impacts of art and design on different cultures. By raising their knowledge of 'the big picture', students can produce essential and influential works of art and design. In response to the decline in arts education, there has been a growing attempt to advocate for the worth of arts education and describe the benefits it may give students and society. According to research, exposure to the arts improves academic success, artistic production, and social and mental growth. Educators and arts groups are working together to better the incorporation of art and design classes in standard syllabi and to raise public awareness of the field's importance. Overall, problems such as a decrease in arts education options, a focus on interdisciplinary methods, and the integration of technology, together with an emphasis on critical studies and societal impacts have shifted the course of art and design education. Despite the challenges of this industry, there is a rising push to revitalise and incorporate art and design education into the standard curriculum.

8.5 Active Learning

Instead of merely sitting back and taking notes, students are encouraged to actively participate in the learning process via active learning. Students in an active learning environment are actively engaged in reading, writing, discussing, and solving problems in order to build their skills and engage in higher-order thinking. In a society that requires more from pupils than rote memorisation, active learning practices strive to foster critical thinking and problem-solving abilities. Active learning exercises at every level of schooling, from elementary to university, and in any field of study are employed. Students often collaborate on in-class projects as part of a variety of active learning methodologies. Students may work in groups to solve problems, act out scenarios, or create something new as part of a learning project. Student agency, peer learning, and perspective-sharing are all fostered via these types of events.

Numerous studies have shown that students learn more effectively and retain more material when they are actively involved in the process. Important abilities like communication, teamwork, and problem-solving may all be honed via active learning. In conclusion, active learning is a method of teaching that encourages students to do more than just sit in class and take notes. Students in an active learning environment are more likely to think critically and solve problems on their own. The advantages of active learning are well documented, and there is a wide variety of active learning methodologies that may be applied to different settings and fields of study.

8.6 Hybrid Active Learning

Students are actively involved in the learning process via a wide range of collaborative and interactive exercises using the hybrid active learning style. This technique relies on the following guiding principles: Hybrid active learning approaches place a premium on individuals' own strengths, passions, and learning styles. This implies that rather than being passive recipients of knowledge, students are actively engaged in the learning process and professors take on the role of facilitators. The system places a premium on student interaction and cooperation. Teamwork, communication, and problem-solving abilities are fostered when students work on assignments and projects in small groups (Luo & Zeng, 2022).

Hybrid active learning approaches are founded on the principle that students gain the most through hands-on, practical experience. As a result, it places a premium on 'learning by doing' and putting theoretical principles into practice. With regard to technology integration, the use of technology is key to modern active learning approaches. Online simulations, virtual laboratories, and multimedia presentations are just some of the digital tools and resources that students utilise to better their education. With regard to continuous evaluation, assessment of student progress in learning is an integral part of the hybrid active learning approach. This makes it possible for instructors to tailor their lessons to the requirements of their pupils and for students to receive feedback on their progress.

Hybrid active learning techniques apply these ideas to create an interactive and productive classroom setting that fosters student learning and growth in areas such as critical thinking, problem-solving, and subject mastery (Capone, 2022). Increasing numbers of schools and classrooms are adopting active learning strategies because of the positive effects it has on students' learning. Reading, writing, and conversation are all examples of active learning strategies that go beyond traditional lectures and note-taking to help students acquire new knowledge and build more complex thought processes. Key features and recent advancements in the trend of active learning include classrooms, study rooms, lounges, and cafes, which may all be turned into 'active learning spaces'. By fostering a range of teaching strategies and student involvement, active learning classrooms aim to create an exciting environment for students. The principal advantage of active learning is that it keeps students engaged throughout the learning process. Students may build long-term retention of knowledge, concepts, and skills by participating in activities that facilitate this.

In the past, lecturing was seen as active participation by academics in higher education. This perspective has now shifted, and active learning is now seen as a teaching method that requires students to take an active part in their own education. Rather than the passive intake of knowledge, participation with teachers and students is the most crucial component of active learning. These characteristics facilitate learning via inquiry, experimentation, and student–teacher communication. Academic libraries have also been affected by the advent of active learning since they have had to adapt to suit the needs of students and instructors using this instructional style. Due to its adoption on a nationwide scale in elementary and secondary schools, the creation of 'active learning spaces' was chosen as the top K-12 education trend for 2018. VR in education is an interactive learning trend that has the potential to revolutionise the delivery of course content. By 2025, it is anticipated that the educational virtual reality market would be valued at $700 million (Mekacher, 2019). Greater student engagement in the learning process has been associated with improved academic achievement. Active learning thus is characterised by the creation of dynamic classroom settings, the encouragement of student participation, and the deployment of innovative teaching and learning strategies. When students participate in active learning, they get a more comprehensive understanding of their curriculum and have higher academic achievement overall.

8.7 Hybrid Active Learning Design Model

A Hybrid Active Learning Design Model integrates the most beneficial aspects of hybrid learning with active learning. Hybrid learning blends face-to-face and online learning, offering students flexibility and personalised learning options. Active learning involves students in the learning process via a variety of activities, fostering skill development and higher-order thought. Here is an early version of a hybrid active learning design model (Fig. 8.1):

- Define learning goals: Establish explicit learning objectives for the course, concentrating on the information, abilities, and competencies that students should acquire by the course's conclusion (Riccomini et al., 2017).

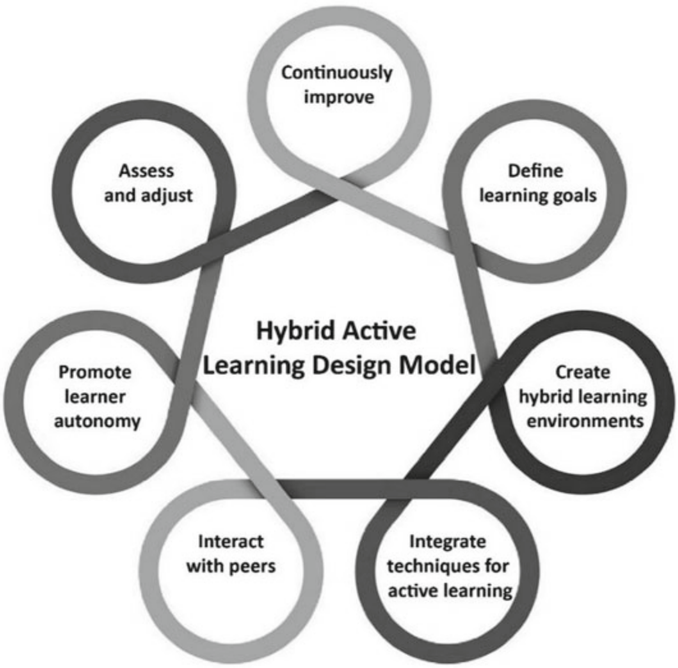

Fig. 8.1 An illustration of the hybrid active learning design model

- Create hybrid learning environments: Choose a hybrid learning strategy that best suits students' requirements and the course material. Consider methods such as the differentiated model and the hybrid flexible model, which enable students to select their manner of involvement and engagement (Nørgård, 2021).
- Integrate techniques for active learning: Include active learning activities, such as reading, writing, conversations, problem-solving, and group projects, to encourage student participation, teamwork, and critical thinking.
- Interact with peers: Utilise technology to promote both online and face-to-face learning experiences by providing students with different learning resources, real-time feedback, and opportunities for interaction with peers and instructors (Nguyen et al., 2018).
- Promote learner autonomy: To better suit their particular learning styles and demands, allow students to choose their preferred form of interaction, whether it be in-person, online, or a mix of the two (Shi & Han, 2019).
- Assess and adjust: Regularly assess the efficacy of the hybrid active learning design model by collecting student input and monitoring their development. Utilise this data to modify and enhance the course's structure, ensuring that it fits the learning goals and promotes student success (Ren et al., 2021).
- Continuously improve: Keep abreast of the most recent studies and best practices in hybrid and active learning. Implement new methods and technologies as needed to continually improve the efficacy of the hybrid active learning design model (Wan & Niu, 2019).

By using this hybrid active learning design model, a learning environment that incorporates the greatest features of hybrid and active learning techniques was developed, while catering to a variety of learning styles and requirements and boosting student engagement and accomplishment.

8.8 Case Studies of Hybrid Active Learning in Art and Design Practices

Two comprehensive case studies of mixed active learning in art and design practices are provided below.

8.8.1 Hybrid Active Learning Makes Use of Both Internet and Face-To-Face Learning Practices

Fuchs (2012) implemented integrated learning in a higher education painting and design course. The study investigates using the internet and face-to-face learning practices to enhance pupil involvement and learning outcomes. A total of 25 student teachers from Teachers College, Columbia University, New York City (TC) in the

USA and 27 from Pädagogische Hochschule Heidelberg (PHH) in Germany participated in this research. PHH pupils were stated English test applicants, whereas TC student instructors were master's degree students in teaching English to speakers of other languages (TESOL) or applied linguistics (AL). The members came from various racial and linguistic groups. They organised themselves into 12 local groups at TC and 13 local groups at PHH, which merged to create 12 cross-institutional groups. Through a customised Moodle learning management system, the eight-week multinational cooperation used synchronous CMC (chat) and asynchronous CMC. The TC training addressed different language-teaching techniques, whereas the PHH school concentrated on task-based language teaching. Student instructors discussed and designed projects with their cross-institutional associate groups as part of the cooperation.

The cooperation was split into three phases: introductory, project, and presentation and evaluation. Student instructors established local organisations, uploaded biographies, and learned about each other's institutional settings during the introductory phase. During the project phase, the 12 cross-institutional groups performed practice tasks based on task-based language-teaching texts, which led to an evaluated final project task. The concluding assignment needed groups to redesign instructional exercises based on TBLT concepts and with a cultural emphasis. In-class presentations, group comments, and teacher input were all part of the presentation and evaluation phase. The researcher collected and analysed the data while also teaching the course at TC and co-designing the project with the Heidelberg teacher educator. Data integration entailed collecting information from pre-course surveys and post-course inquiries using qualitative and summary statistical data. Participants' digital abilities, language learning choices, previous group work, cross-cultural encounters, and course goals were all evaluated in the pre-course assessment. The post-course questionnaire included four open-ended questions and an additional comment section that focused on what participants learned and their motivation to try a similar project in their teaching. Participants were invited to provide suggestions for learner and teacher training as well as a summary of the project's benefits or lessons that were learned. The post-course assessment was designed to help student instructors reflect on their cooperation with cross-institutional partner groups and consider how to implement what they had learned in the classroom. The pre-course surveys were returned by 23 out of 52 student teachers (44.23%), whereas the post-course questionnaire return rate differed because not all student teachers answered all of the questions. Regarding the post-course surveys, 22 student instructors (42.31%) responded to most inquiries. The study aimed to investigate the topics under consideration without attempting to generalise beyond this group. The researchers used open coding to create codes and categories from the data rather than pushing them into pre-existing categories from the literature. Two programmers categorised the codes by grouping them around events connected to the study topics and then linking such categories to in vivo codes, that is, abstract codes obtained from the participants.

The findings revealed that student instructors self-rated their previous technology-related experience, internet competence, and language learning inclinations. Word editing, internet search tools, and email proficiency were all rated highly (Fuchs, 2012). In terms of language learning choices, student instructors prioritised group work, joint work display, and internet use in foreign language instruction. According to post-course evaluation findings, most student instructors learned about the challenges and advantages of teamwork, organisational elements, and communication. Several respondents cited learning about various views and institutional contexts as benefits of cooperation. More help with technology, better standards and instructions, and more attention to ethnic variations were proposed improvements for future initiatives. In a survey of student instructors, 50% said they were ‘delighted’ with their end output, while 13.64% said they were ‘satisfied, but…’ and the same number said they were ‘somewhat’ satisfied. Those who were dissatisfied mentioned problems with collaboration and communication. Participants felt that straightforward directions and discussion of potential issues and cultural variations were essential for success in similar projects. Student instructors’ desire to attempt a similar project in their teaching differed: 40.90% said they would adopt a reduced form, while 31.82% emphasised the advantages of promoting cooperation and expanding horizons. However, 27.27% found the concept intimidating due to problems such as punctuality, technology, and confidence.

Language instructors perceived advantages from being prepared in the classroom, straightforward teaching, task-based learning, computer-assisted language learning, textbook review, and collaboration. Technology assistance, instructor experience with wikis, newsgroups, conversations, and tackling issues and cultural variations were all suggested for future student and teacher training in similar initiatives. Despite the potential for increased closeness and urgency, only one student instructor proposed incorporating more simultaneous tools such as MSN, Facebook, and Skype for better computer-mediated talks.

8.8.2 Application of the Technological Development Cycle in Hybrid Active Learning

Jahnke et al. (2022) studied the implementation of a mixed active learning model in a digital art and design course. The training followed the technological development cycle, which entails planning, developing, testing, and refining a digital prototype. It also used the digital didactic-design course-development framework, which stresses the positive integration of teaching/learning objectives, active learning methods, summative assessment, social structures, and technology use. The instruction was divided into five sessions, each lasting two hours. These workshops aimed to enable the teaching team to provide insight and motivation while allowing students to share their achievements, ponder previous actions, and receive feedback from classmates and teachers. Workshop 1 concentrated on team and concept creation, with the instructor outlining the course goals and prerequisites while students made groups and brainstormed ideas. In Workshop 2, which concentrated on storyboarding and development platforms/software, each group discussed their basic frameworks and storyboards, received feedback, and was introduced to the mobile UI development tools ARIS and GuidiGO. In Workshop 3, groups showed their first designs and received feedback on improving them. In the workshop's second half, user testing methods were introduced, and groups began creating testing tactics for their apps. In Workshop 4, groups shared the results of their usefulness or user experience study and received feedback on improving their apps. Workshop 5 was a showcase day and gathering where groups displayed their finished gamified apps. The gathering included a welcome, group speeches, a performing exercise, and the declaration of the victors. Expert group assessments and a public poll determined the best designs. Groups used Google Drive to exchange material and receive papers from the teacher between seminars and Slack to communicate with the educator and pupils.

The preliminary research used a combination of techniques, including focus groups with 3–5 students per group and pre- and post-questionnaires. The purpose of data gathering was to document the pupil group learning process and personal views. Students from different fields were selected to handle computational reasoning tasks. At the beginning and conclusion of the course, focus groups were held, with an organised interview procedure encompassing group activities, the design and development process, duties and responsibilities, communication tools, and wrap-up questions. Online surveys were also used at various points of the training. Thematic analysis with open coding was used to analyse the qualitative data, and the research was led by role theory. In a class of 15, one pupil bowed out after the first session. The remaining 14 were drawn from various fields and had different degrees of schooling. They were motivated to participate by networking, job possibilities, and learning new tools. Students were given various tasks, such as designing material or making storyboards. They were divided into four groups, each developing a different gamified AR game. Their experiences differed, with some groups finishing prototypes effectively and others facing difficulties with software, code, or teamwork. Participants acquired knowledge and skills relevant to their assigned duties and views on digital design and development projects.

The findings of the follow-up and post-questionnaires indicate that students were generally satisfied with the course, resources, tools, active involvement, and meaningful efforts. However, happiness levels varied, and some students felt they needed more direction and assistance from the teacher. Regarding group projects, all groups worked on app concept development but with varying degrees of success. Group 3 made the most headway, progressing to a co-design learning stage and producing a partly functional innovative version. While the study found a link between active learning and improved results, more research is required to prove this.

Various variables may prevent students from becoming critical co-designers in collaborative projects. Practical cooperation can be improved by effective leadership to tackle a lack of confidence among group members. Some students may feel constrained by the course design or need to recognise that they can choose their strategy and instruments. Clear dialogue, introspective mentoring, and innovation techniques can be used to support critical group co-design. Incorporating process-based assessment methods and urging students to take ownership of their learning can also promote co-design.

These case studies illustrate how hybrid active learning may be applied effectively in art and design courses to improve student engagement and learning results. By using active learning practices and merging online and face-to-face learning activities, teachers may create a more dynamic and engaging learning environment for their students than was previously possible.

8.9 Conclusion

Hybrid active learning is a form of instruction that blends face-to-face and online learning strategies to improve student engagement and learning results. In recent years, hybrid active learning—encompassing art and design education—has gained appeal in the area of education. This chapter explores the findings of academic research on the efficacy of hybrid active learning in art and design education, emphasising the trend of this method and the possible issues that must be considered. Due to its adaptability and facilitation of the learning process, hybrid active learning has arisen as a trend in art and design education, according to the study. It has been shown that hybrid active learning increases student involvement and participation while fostering critical thinking and problem-solving abilities. One research study found that students in hybrid active learning courses performed much better academically than those in standard lecture-based courses.

Despite the positive outcomes of hybrid active learning, it is necessary to keep in mind a few possible issues to assure its efficacy in art and design education. The necessity for good communication between students and teachers is a crucial factor to consider. As hybrid active learning mixes in-person and online learning, communication may be difficult, particularly if students are unfamiliar with online tools and platforms. Therefore, educators must give clear instructions and training so that students may efficiently use internet platforms and resources. Another factor to consider is the need for adequate technical infrastructure and support. Hybrid active learning requires dependable and steady internet connections and access to the right technological tools and software. Without enough infrastructure and support, the efficacy of hybrid active learning and the learning experiences of students may be undermined.

In conclusion, hybrid active learning has evolved as a trend in art and design education, offering an effective strategy for boosting student involvement, participation, and academic accomplishment. To guarantee its efficacy, however, educators must offer good communication and training for online tools and platforms as well as an adequate technical infrastructure and support system. By resolving these possible issues, hybrid active learning may continue to be a successful method for teaching art and design.

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Chapter 9
Empathizing with Students with Disabilities (SWDs): A Design Thinking Perspective

Michael Agyemang Adarkwah and Samuel Amponsah

Abstract Students with disabilities (SWDs) are among the most marginalized group of learners who may struggle to acquire the knowledge and skills needed to provide authentic solutions to real-life problems. As a result, policymakers and educators have recognized rethinking design for inclusiveness as a means to provide support for and meet the needs of such learner cohorts. This rethink has resulted in the adoption or adaption of the design-based learning (DBL) approach which seeks to improve the learning experience of SWDs through five iterative design thinking (DT) processes: empathize, define, ideate, prototype, and test. It is important to note that the prevailing literature has largely taken a generic look at the application of the DT processes in inclusive settings. This chapter thus critically focuses on the first process of DT (empathize) to facilitate deep engagement between designers and SWDs as a strategy for reducing instructional barriers and aiding the development of their problem-solving skills. The theoretical analysis of the literature concludes with a proposed model which highlights four key factors (environmental, classroom, teacher, and student factors) as enablers for instructors to demonstrate empathy in inclusive settings. Moving forward, we recommend a participatory design approach through the consideration of the four interrelated factors in the proposed model when constructing the educational process of SWDs. Also, a supportive and disability-friendly learning environment should be created for SWDs in terms of architectural and instructional design.

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9.1 Introduction

Students with disabilities (SWDs) are considered an at-risk population due to the failure of educational institutions, mostly from developing economies, to create a learning milieu that promotes the development of authentic problem-solving skills and knowledge. In comparison with their abled counterparts, SWDs are often excluded from forms of learning that involve high-level concepts and high-order thinking. For example, those with learning disabilities exhibit a cognitive process and working memory traits that may not align with instructional principles designed for any "regular" learner (Greer et al., 2013). Additionally, "non-disabled" students may feel uncomfortable participating in classroom projects with their "disabled" counterparts in mainstream schools (Nichols & Quaye, 2008). This results in a form of alienation that prevents school leaders and teachers from noticing the needs of SWDs.

While it is necessary for SWDs to construct the knowledge and skills needed to design products for real people or users, SWDs are faced with a myriad of educational challenges that hinder them from actively engaging in design solutions to real-life problems. That is, creating an unparalleled educational setting that is inclusive in nature and facilitates the creativity and critical thinking ability of students with visible impairments (e.g., hearing and visual) and invisible disabilities (learning and psychological disabilities) should be a priority of contemporary schools.

The above brings to the fore design-based learning (DBL), which is described as an innovative method to create equitable classrooms (Miller et al., 2021) where the academic and social engagement of diverse learners is not obstructed (Metatla et al., 2018). DBL, as an interactive teaching and approach, is designed to be inclusive in nature (i.e., suitable for all learners irrespective of their skills or abilities) and combines problem-based learning with project-based learning to situate learners in meaningful and in attractive and real-life situations where they are allowed to apply their existing knowledge and problem-solving skills (Azizan & Abu Shamsi, 2022; Tsai et al., 2022).

Past studies have found DBL methods to yield strong engagement among SWDs and stimulate those with less severe disabilities to have compassion for those with severe disabilities (Belland et al., 2006), promoting inquiry (Tsai et al., 2022), and increase the motivation and achievements of SWDs (Zhang et al., 2020). DBL applies the principles of design thinking (DT) which involve five (5) iterative processes: empathy, define, ideate, prototype, and test (Zhang et al., 2022).

In this study, DT is conceptualized as a mental representation process in which human beings intentionally transform information, knowledge, technology, and ideas into innovative practices such as products, works, and services. This study makes use of Tim Brown's "3I Model" which encapsulates three elements namely inspiration, ideation, and implementation. Inspiration pertains to people-centered exploration and analysis, gaining empathy for user problems through observation, survey, interview, and other qualitative research methods, and determining the problems to be solved. Ideation has to do with cooperation and communication to actively generate as many ideas as possible to solve problems. Implementation involves the process of prototyping ideas, testing, and iterating until the final design is accepted. In the estimation of Harden and Moore (2019), a participatory DT process engenders designers to create effective and adaptive learning tools that promote engagement among SWDs and their abled counterparts.

Existing studies have largely taken a generic look at the application of the DT processes in inclusive settings. For example, Metatla et al. (2018) call for a design thinking approach to foster an inclusive technology design for SWDs without highlighting which of the iterative design processes or models should be the primary focus. Izzo and Bauer (2015) proposed the application of universal design for learning (UDL) principles for the application of technology hardware and software to enhance the achievement and employability of SWDs but provided little information on the essential factors that hamper the success of integrating UDL principles. Besides, very few studies offer design solutions that school leaders or administrators can implement to ensure teachers instructing in inclusive classrooms use pedagogical strategies that meet the learning needs of SWDs.

In light of the foregoing, this chapter critically focuses on the first process of DT based on Tim Brown's "3I Model" (inspiration), which by definition corresponds to the first process (empathy) of the "EDIPT Model" from Stanford University School of Design (Zhang et al., 2022). The idea is to facilitate deep engagement between designers and SWDs as a strategy for reducing instructional barriers and aiding the development of their problem-solving skills. Additionally, we propose a conceptual framework that identifies the critical factors that designers should take into consideration when planning learning activities for SWDs. We hope that the information provided in this chapter will lead to a broader discussion on how designers and teachers can foster empathy and the role of empathy in stimulating the design thinking of SWDs.

The rest of the chapter is as follows: Sect. 9.2 presents a literature review on the educational challenges of SWDs, the design thinking perspective for learning, and the concept of empathy. Section 9.3 discusses the conceptualized model by describing the nexus between empathy and SWD instructional design. Lastly, Sect. 9.4 provides the way forward for the implementation of DT for SWDs.

9.2 Literature Review

9.2.1 Educational Challenges of SWDs

Sustainable Development Goal 4 (SDG4) is arguably one of the most ambitious goals as it seeks to ensure inclusive and equitable quality education for all and also promote lifelong learning. However, achieving this goal may be a mirage as students with disabilities (SWDs) continue to face critical challenges in their studies. For instance, Kotera et al. (2019) identify an increase in the number of students with disabilities in the United Kingdom without commensurate support to facilitate their online learning. The authors classified the educational challenges of SWDs as physical, technological, systemic, financial, or attitudinal.

Globally, funding for educational institutions keeps dwindling and the allocation of SWDs leaves much to be desired. Kotera et al. (2019) lament the complicated and restricted qualification criteria which in their opinion contradicts human rights dictates. This is corroborated by Ferati et al. (2016) who identify stigma and constraints as major challenges SWDs face in their bid to access financial aid.

Several international and national treaties have concentrated on inclusive education. These include the Millenium Development Goals and SDGs which both recognize education as an imperative for human development and sustenance. It is, therefore, worrying that studies continue to reveal that the physical infrastructure of some educational institutions is not disability-friendly. In Braun and Naame (2021), it came out that all higher education institutions selected for their study had buildings, roads, and facilities that were not accessible to SWDs. Aside from the challenges with accessibility to physical infrastructure is that of digital technologies. Studies by Adarkwah (2021) and Amponsah (2021) revealed the inadequacy of digital tools for such a cohort of students.

Furthermore, the confusion between accessibility and usability presents a key challenge to SWDs. Amponsah (2021) asserts that in as much as educational institutions are increasing access to facilities and digital tools. The prevailing literature has not focused on the usability of such tools. In separate studies in the USA and Africa, respectively, it was found that the interfaces of most college websites were either inaccessible or incompatible with software for visually impaired students (Agangiba & Agangiba, 2019; Irwin & Gerke, 2004).

Moreover, it is quite worrying that in the age of human rights, studies conducted as recently as 2022 revealed that SWDs are still facing challenges with stereotyping and negative attitudes. The Ontario Human Rights Report (2022) reveals that the lack of appreciation of the sensitivity of disability issues causes some educators to discriminate against SWDs. The net effect of such behaviors is the inability of SWDs to make and maintain friends in schools. Thus, leading them to live and learn in isolation.

The last challenge presented in this review touches on the lack of expertise to handle SWDs in educational institutions. Amponsah's (2021) study identified that while lecturers and staff have not received any training on accommodating SWDs in their classrooms (virtual and physical) and offices they call at, respectively. It was not surprising for a visually impaired student to refer to her cohort as "silent minority" in the said study. Under such challenging circumstances, Nichols (2020) opines that the curriculum may be rendered useless to SWDs. Thus, a call to optimize efforts through DT approaches in order to circumvent their complex and numerous challenges.

9.2.2 Design Thinking Perspective for Learning

The DT process is an innovative and problem-solving approach popularized by Tim Brown (2009) and has gained recognition as a valuable framework for addressing complex challenges across various areas. In the estimation of Wolniak (2017), the principal focus of DS is to build innovators who can use the DT paradigm to transform ideas into reality, to transform organizations, and to transform all aspects of life. Thus, the implementation of DT in educational curriculum and thinking has the potential to churn out students who would excel beyond the "normal," help resolve societal challenges with practical solutions and become generational thinkers. As rightly pointed out by Schallmo et al. (2018) DT has been applied to many fields of study and has proven to wield power that can help transform the way people work by transforming the way they think, approach problems, and develop products and services.

Theoretically, DT aligns with several models of learning. Key among these is constructivism which revolves around students continuously constructing knowledge via interactions with others and with their environment (McPhail, 2016). This brings to the fore the human-centered orientation of DT that places a strong emphasis on empathy, collaboration, and experimentation at its core (Zhang et al., 2022). It emphasizes understanding the needs and perspectives of learners, generating creative ideas, and rapidly prototyping and testing solutions. The iterative process of the DT inspires open-mindedness, embraces failures as opportunities for learning, and continuously refines designs based on learners' feedback.

Moreover, the process offers noteworthy benefits when applied to learning in higher education institutions by actively engaging learners in authentic, real-world problem-solving which in turn helps learners to cultivate a sense of relevance and motivation. It also encourages multidisciplinary collaboration and the integration of diverse perspectives, mirroring the complexity of today's global challenges. Furthermore, DT equips learners with essential skills, including empathy, critical thinking, communication, and creativity, which are highly valued in the contemporary workforce. These align with the two facets of DT that Goldschmidt (2022) introduces to the discourse. Thus DT as descriptive models based on observational research of real-life or laboratory activities and secondly as a method practiced in the industry to introduce innovative products and services.

Like other models underpinning education, the principles and methods of DT can be effectively applied in the context of learning within higher education contexts. This review thus explores how DT can enhance learning experiences, foster creativity, and develop critical thinking skills among learners. Firstly, design-based learning (DBL) is an innovative educational approach that incorporates the principles of DT into the learning process. With a particular emphasis on empathy, this methodology empowers learners to develop creative problem-solving skills, cultivate a deep understanding of other's perspectives, and create meaningful solutions (Brown, 2009).

Inspired by Tim Brown's original five-step process, the first step in DBL is to cultivate empathy whereby students are encouraged to understand and appreciate the needs, experiences, and challenges of others. By adopting an empathetic mindset, students gain insights into diverse perspectives which promotes inclusive collaboration and fosters a deeper understanding of the problems they are confronted with. Empathy is a fundamental aspect of DT and it plays a pivotal role in the context of learning. By developing an empathetic mindset, learners can better understand the needs and experiences of their peers, instructors, and other stakeholders. Empathy fosters inclusive learning environments, promotes effective communication and teamwork, and enhances the ability to design solutions that address the real needs of individuals and communities.

In this context, educators can incorporate various strategies into their teaching as a strategy for integrating DT into their curriculum. For example, educators could create project-based assignments and field-based tasks that simulate real-world challenges to enable students to apply DT principles and methods in their learning. As held by Sandars and Goh (2020) in their study of DT in medical education:

> This approach not only increases the implementation of design thinking but also highlights the adaptable use of design thinking skills across different curricular themes. For example, design thinking has been successfully integrated into medical student ethics teaching about organ transplantation and interprofessional learning about aging and disability (Sandars & Goh, 2020, p. 3).

With the evolution of technology, including artificial intelligence, students would be seriously short-changed if they were taught or allowed to think like students of yesterday. It is in this light that Gonen (2020) concludes that DT speeds up the creation of new products and improves teamwork. To wit, the application of DT in education could unlock the potential of students, who construct knowledge and solutions to solve their personal and societal problems. To this end, it is important to understand that knowledge creation has emotional attachment which also creates a sense of agency and ownership of the process and solution. Consequently, Brown (2009) asserted that every successful innovation should take into account the experiences and emotional reactions of the user. In the context of this study, every successful innovation or solution should take into account the emotional experiences and attachments of the students who developed the solutions. This can best be attained through the application of DT in the educational ecosystem.

Though DT has proven to be a reliable model for revolutionizing education, it has its drawbacks which have resulted in some criticisms against its application. For instance, Gonen (2020) discovered that it is not conducive to solving complicated systematic issues and intricate systematic problems. The literature has also identified limitations concerning the applicability of DT which could lead to methodological failures, sometimes ineffective in enhancing students' creativity and self-efficacy, slow development of skill-based learning, and a potential avenue for team conflicts (Ohly et al., 2017; Valentim et al., 2017; von Thienen et al., 2014).

Despite these drawbacks, the [potential] benefits of DT abound in the literature. In addition to those enumerated earlier, Panke (2019) opines that DT helps deal with ambiguities while articulating the right questions to enable the formulation of possibilities and potentials. In view of its strengths, DT could provide a valuable framework for enhancing learning experiences in higher education institutions. By embracing empathy, collaboration, and experimentation, students can develop critical skills that could prepare them for the challenges of the future. Thus, integrating DT into the curriculum and creating supportive environments holds the potential to transform education into a more engaging, student-centered, and innovative endeavor.

9.2.3 The Concept of Empathy

Empathy is identified as the initial step in the conventional DT process by the Stanford University School of Design and a central task in design (Zhang et al., 2022). Goldman and Zielezinski (2021) allude that DT relies on an empathy-driven orientation and serves as the foundation of the entire problem-solving process. That is, DT places an onus on empathy to provide an opportunity for authentic dialogue in each stage of the DT process (Storm & Smith, 2023). In a general sense, empathy is defined as the ability to detect and understand the emotional state of other people or the reason behind their actions (Melo et al., 2020). With regard to DT, empathizing is the experience of getting to know and comprehend an individual's condition by identifying with the individual's experiences and perspectives (Goldman & Zielezinski, 2021).

From the foregoing, empathy has become instrumental for any organization seeking to improve human experience and is discussed among the essential twenty-first-century skills (Matthews et al., 2017). Following Tim Brown's "3I Model," the concept of empathy is embedded in "inspiration," which is conceptualized by Brown and Wyatt (2010) as the problems or opportunities that motivate us to look for solutions. Inspiration requires gaining empathy for a user's problems, while empathy aids designers to move past consumers (students in our case) as subjects or consumers and experience what they do (Brown, 2009) and observe the world from multiple perspectives and in minute detail (Brown, 2008). In the study by Storm and Smith (2023), "Empathy" is referred to as "Inspiration, Hear, or Challenge" (p. 8).

Kim et al. (2022) mention that in DT, empathy has to do with intellectually identifying with the emotions, ideas, and attitudes of people and can be developed through meticulous observance of people to discover their explicit and implicit needs. It is worth noting that understanding human behavior is essential for the design of a tailor-made artifact for users. Empathy is the way designers understand users' needs, experiences, and desires and serve as the basis for any product development such as the construction of a curriculum for SWDs and also serves as the basis of inclusion and diversity (Altay & Demirkan, 2014; Heylighen & Dong, 2019; Storm & Smith, 2023). According to Storm and Smith (2023), the idea of empathy.

Furthermore, empathy ensures that the needs of all people who will eventually be recipients or end-users of a design should remain the central focus during problem-solving (Goldman & Zielezinski, 2021).

In order to empathize, a designer (in our context educators and teachers) has to understand the behavior of users, engage with users through interactions, and immerse themselves in the experience of users (Peng, 2022). This is to say that empathy is more than knowing and does not involve judgment but immersing oneself in certain experiences meaningful to other people (Kouprie & Visser, 2009). "Empathy, an emotional understanding, is achieved precisely by leaving the design office and becoming—if briefly—immersed in the lives, environments, attitudes, experiences and dreams of the future users" (Battarbee et al., 2002, p. 243). A user-centered or human-centered design, experience-centered design, and goal-oriented design all recognize empathy as one of the most potent tools designers have to offer (Heylighen & Dong, 2019).

That is, an empathetic approach toward the instructional delivery of SWDs will result in authentic thinking and creativity. That is, an empathetic view of the concerns and needs of SWDs will enhance their skills and make them problem-solvers. This is why universal design for learning (UDL), which is an inclusive design or design for all, is believed to be driven by empathy with the common understanding that one size doesn't fit all (Heylighen & Dong, 2019). In this light, the concept of empathy has been applied as a design technique for people with neurological, psychological, or learning disabilities (Melo et al., 2020). Particularly, in the instructional design for learners of any age group or with different abilities, instructional designers are encouraged to express empathy when designing learning content although evidence exists that they are often not empathic toward learners (Matthews et al., 2017). From the foregoing, one can allude to the fact that an empathetic approach to instructional design and delivery will give SWDs the opportunity to express their ideas and thoughts.

The literature review has illustrated that SWDs encounter several educational challenges which threaten the achievement of SDG4, specifically, Target 4.5, which calls for inclusivity in learning. In this light, a DT perspective for learning is presented as an effective means to help resolve educational challenges with practical solutions. In implementing a DT approach to learning, empathy is observed to be fundamental to the entire problem-solving process. In the next section, a model consisting of four interrelated factors is proposed to illustrate how designers can achieve an empathetic design for SWDs.

9.3 The Nexus Between Empathy and SWDs Instructional Design

The focus of an empathetic design is to enable designers (teachers) to build a comprehensive cognitive and affective understanding of the user (students) which will lead to user-friendly design outcomes and enable a designer (teacher) to understand the fears and appreciate the challenges of SWDs (Altay & Demirkan, 2014). Empathy and care are highly valued by SWDs in their educational journey. While for teachers,

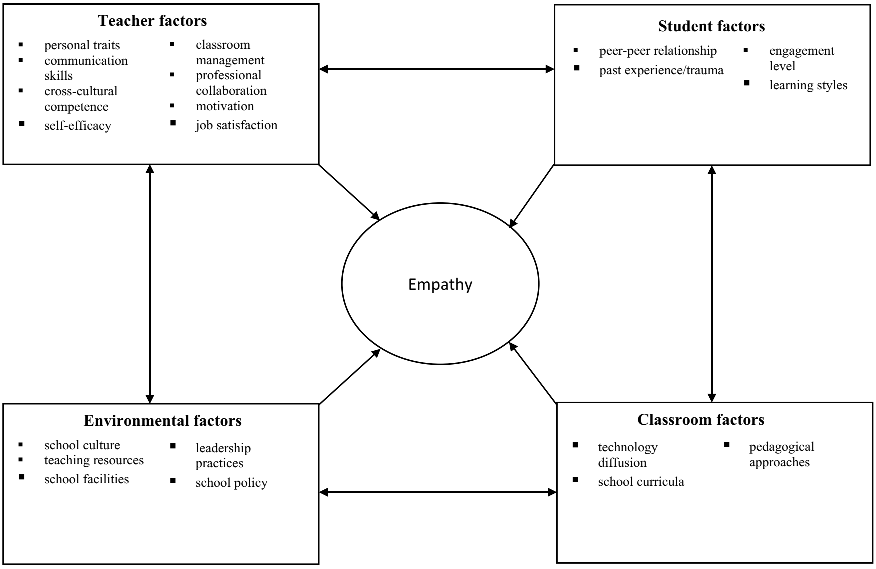

Fig. 9.1 The four interrelated fundamental factors in empathizing with SWDs

empathy is fundamental to their success as professionals (Moriña & Orozco, 2020a, 2020b; Stojiljković et al., 2012). According to Bennett and Rosner (2019) applying empathy in design is more important when students have disabilities. Given the preceding, we propose four (4) fundamental factors of empathizing with SWDs that designers need to be aware of; teacher factors, student factors, classroom factors, and environmental factors (see Fig. 9.1).

Teacher Factors: Teacher dispositions and personal traits such as emotional intelligence, patience, empathy fatigue, compassion, beliefs, values, attitudes, etc., can affect how they incorporate empathetic practices in their teaching (Moriña, 2019; Navarro-Mateu et al., 2019; Stojiljković et al., 2012; Wang et al., 2022). For example, Moriña and Orozco (2020a, 2020b) mention that the attitudes of faculty have an effect on the success and permanence of SWDs. The authors further add that teachers are arguably the most important stakeholders in both the classroom and in the lives of SWDs. A similar finding also revealed that faculty's recommendation for the demonstration of patience and empathy by teachers toward SWDs will enable them to be better professionals and help them to better listen to and support SWDs (Moriña & Orozco, 2020a, 2020b). Additionally, teacher competence in communication, acculturation, or dealing with diversity, and in socio-emotional learning practices can affect their demonstration of empathy toward students (Navarro-Mateu et al., 2019). As reviewed in the literature, one of the highlighted challenges of SWDs is attitudinal (Kotera et al., 2019) and teacher factors that affect the learning of SWDs (Amponsah, 2021). Moriña and Orozco (2020a, 2020b) call for the demonstration and application of universal design of learning (UDL) principles by faculty as an empathetic approach to teaching.

Also, teachers with better communication and listening skills would be more effective in identifying students' learning needs and finding ways to offer support (Moriña & Orozco, 2020a, 2020b). Another teacher-related factor that can affect their empathetic practices in teaching includes their self-efficacy (Goroshit & Hen, 2016) and the classroom management strategy they adopt (Wink et al., 2021). Teachers need to have a high command of the classroom and create an inclusive and supportive atmosphere to enable different types of learners to freely explore and express themselves (Navarro-Mateu et al., 2019). Professional collaboration among teachers also helps create an empathetic relationship among teaching staff which translates to their relationships or interactions with students (Campbell, 2022; McGowan et al., 2021). Lastly, teacher motivation and job satisfaction in a way dictate how they interact with students and teaching quality (Ge et al., 2021; Parchomiuk, 2019).

Student Factors: Peer-peer relationships among students affect their emotional state, self-confidence, self-efficacy, etc. That might encourage or compromise their creative skills and their ability or willingness to communicate their challenges to teachers. In the study by Rieger and Rolfe (2021), students without disabilities entered the world of their disabled peers by closing their eyes as a way of helping them to acknowledge what it means to have a disability. This in turn helped the non-disabled students to develop appreciation and empathy toward SWDs. In such situations, SWDs would be more willing to express their concerns freely to their peers or teachers for help. As mentioned earlier, the lack of sensitivity to disability issues results in the social isolation of SWDs (Rights Report, 2022). Designers (teachers) will not be able to comprehend users (students) who cannot express their real or authentic experiences (McDonagh, 2015). In this light, teachers might not be able to fully understand the learning difficulties of students. Learner voices or ways for them to express their concerns is integral to applying empathy in design (Gronseth et al., 2021).

Students who have experienced or are recovering from a bizarre experience or trauma might require a special demonstration of empathy from teachers (O'Toole & Dobutowitsch, 2023). Teachers will need to understand the causative and precipitating factors of the trauma to be able to provide individualized support or nurturing environment for the students. That is, the psychological state of a student might demand varying demonstrations of empathy. To be able to show empathy or establish a learner-friendly environment, teachers will need to develop an uncritical understanding of the inner thoughts of students, see things from their point of view, and offer them care and support (Wang et al., 2022). In one study, faculty members stated that the empathy they developed in teaching SWD made them realize the significance of helping such students which resulted in the teachers making all efforts to provide and care for them (Moriña & Orozco, 2020a).

Moreover, the level of student engagement and their learning styles might determine the special care and compassion teachers demonstrate to a particular student (Amponsah, 2020; Hagenauer et al., 2015). Teachers tend to pay more attention to high-performing students (Bardach et al., 2021). In some instances, more attention is given to low-achieving students (Denessen et al., 2020; Loveless et al., 2008). However, teachers need to balance attention between high-performing students and low-performing students. They also need to appreciate the individual learning styles of the SWDs.

Classroom Factors: Technological diffusion in the classroom is central to how teachers relate with or demonstrate empathy to their students (McGowan et al., 2021). When reviewing the challenges of SWDs, it was mentioned that the inadequacy of digital tools for a cohort of SWDs presents a challenge to their studies (Adarkwah, 2021; Amponsah, 2021). Technology can help teachers personalize education to meet the learning needs of teachers. For example, learning management systems (LMS), video conferencing tools, and online discussion forums promote effective communication between teachers and their students. In this way, teachers will be privy to the needs of SWDs and personalize learning to address their emerging needs. Also, technology allows teachers the ability to track the learning progress of students in real time, visualize educational content, and conduct simulation that promotes students' understanding of teaching content to promote personalized and adaptive learning among SWDs. At the same time, the ineffective use of technology might affect how teachers detect the emotional states of SWDs, and SWDs who cannot afford digital tools might experience difficulties in learning in technology-enhanced learning environments. Another way technology can be used to foster teacher demonstration of empathy is by using technology to perform a simulation where a teacher becomes a parent of a virtual child with a disability (Scorgie, 2010).

The school curriculum can also affect the demonstration of empathy toward students (Cooper, 2004). Therefore, the school curriculum should be designed in a way that does not increase the workload of teachers and promote the academic success and personal development of students. For example, curriculum demands can result in a decline in empathy (Levett-Jones et al., 2017). Moriña and Orozco (2020a, 2020b) add that the school syllabus can itself be "disabling" and can be a catalyst for the exclusion and oppression of SWDs. Instructional designers should tailor their school curriculum to the needs and interests of students in order for teachers to comprehend the learning experiences of students (Gronseth et al., 2021). A disconnect between the needs and interests of students and the school curriculum might create a struggle for teachers to deliver customized teaching contents that address the learning challenges and enhance the knowledge of students. Consequently, teachers would be less likely to demonstrate empathy in their pedagogical practices. A tailored school curriculum can serve as a bridge that connects teachers and students so it can positively affect educational quality.

Environmental Factors: The ambience of the school environment affects how teachers demonstrate empathy in their teaching practices (Cooper, 2004; Sellars & Imig, 2021). For example, it was emphasized earlier that the physical environment of some educational institutions is not disability-friendly (Braun & Naame, 2021). The school environment should be inclusive in nature to foster empathy in teaching and learning. A high-quality education cannot be considered as such unless it is inclusive (accessible and fair to everyone) in nature (Moriña & Orozco, 2020a, 2020b).

The environmental factors include the school culture, teaching resources available and school facilities (Vučinić et al., 2022), leadership practices, and school policy (Sellars & Imig, 2021). First, the ethos of the school should promote a community of inquiry or inquiry-based learning practices (Schertz, 2006) where teachers and students can freely interact to address learning challenges to improve learning outcomes. The school culture should stimulate teacher compassion for students for them to provide supportive learning practices toward students.

Schools that provide adequate teaching resources for teachers to equip teachers in order for them to effectively support student learning and meet their needs. Example of such resources includes a comprehensive lesson plan and teacher guides or manuals that emphasize rendering care to students, digital resources that facilitate personalized and adaptive learning practices, resources for tracking the progress of students and for quality assessment purposes, as well as both digital and paper-based textbooks. Moriña and Orozco (2020a, 2020b) opined that institutional support, administrative services, and professional coordination are all fundamental to the academic success and retention of and serve as a demonstration of empathy toward SWDs.

When school leaders demonstrate empathy toward teaching staff, teachers are motivated to translate the empathetic behavior of the leaders to their students. For example, when school leaders are interested in identifying the challenges facing teachers to be able to address them, providing effective channels for communication, and appreciating and rewarding the efforts of teachers, they create a blueprint for teachers to follow in dealing with their students. Such efforts are likely to whip the interest of teachers to be more interested in understanding and addressing the learning needs of individual students.

School policies should emphasize teacher accountability regarding empathy when delivering learning content to students (Meyers et al., 2019; Smith, 2021). That is, empathy should be included as an important teaching component and clear guidelines should be provided to teachers for them to demonstrate and be accountable for empathetic practices in their teaching. If teachers are able to step in the shoes of SWDs and imagine how it feels to have an impairment, it can help teachers see disability differently and understand the situation of SWDs (Bennett & Rosner, 2019; Lambert et al., 2021). School policies should also encourage social-emotional learning (SEL) that will help teachers identify the personality traits of students (Tuomi, 2022). That is, the closer a designer comes to the actual user (experiencing the user's emotions), the more it becomes easier for the designer to know the situation of the user. Mattelmäki et al. (2014) expound that, learning about a user's emotions helps in developing a product they like or find useful.

School policy should also call for empathetic reasoning when dealing with disciplinary issues relating to students. Teachers should be trained in order to be ready to identify the underlying cause of a student's action and find ways to support them instead of relying on punitive measures (Romero et al., 2020). School policy should also emphasize the need for teachers to engage in professional training or development programs that foster empathetic practices in teaching (Peck et al., 2015).

The professional development activities in the form of mentorship, workshops, seminars, and conferences should focus on enhancing teacher understanding of the needs and emotional states of students in order to demonstrate empathetic teaching. Moriña and Orozco (2020a, 2020b) documented that past experience and training in disability are fundamental to the demonstration of empathy toward SWDs and faculty members who offered support to SWDs were those who were aware and had received training in the needs and characteristics of such students. In order to foster empathetic strategies toward SWDs, there is also a need for the training of faculty on UDL principles (Bunbury, 2020; Sakız & Sarıcalı, 2018).

9.4 Way Forward for the Implementation of DT for SWDs

The proposed model (Fig. 9.1) which highlights the four fundamental factors of empathizing with SWDs that designers need to be aware of will help in creating a disability-friendly environment for SWDs through careful implementation. Design thinkers today can benefit from the discussion of the conceptual idea of empathetic design in education. Throughout the chapter, it has been argued that SWDs are confronted with educational challenges which can be detrimental to their construction of knowledge, creativity, and problem-solving skills if not properly addressed. By applying the design solutions proposed in the form of the consolidated model of fostering empathy in inclusive settings, designers will be able to offer innovative remedies to the educational challenges of SWDs. The issues raised in the chapter serve as a launching pad for further investigations on applying design thinking principles in promoting equity in education. Moving forward, a participatory design approach is recommended through the consideration of the four interrelated factors in the proposed model when constructing the educational process of SWDs (see Fig. 9.1).

Regarding teacher factors, it is proposed that in inclusive settings, recruiters should hire more teachers with disabilities than non-disabled teachers. For example, Dvir (2015) opines that teachers with disabilities are often motivated to adopt multicultural educational methods and are more enthusiastic when instructing SWDs. They go beyond the school curriculum to share their educational experiences and personal stories with SWDs. Since the concept of empathetic design demands teachers to step into the shoes of SWDs (Bennett & Rosner, 2019; Lambert et al., 2021), teachers with disabilities will be more knowledgeable and passionate about the feelings of SWDs and design artifacts or pedagogical strategies tailored to the needs of SWDs. Additionally, when dealing with individual students, teachers can create an empathy map to gain a shared understanding of a particular user's needs, behaviors, thoughts, and feelings (Bennett & Rosner, 2019). The anticipated gains can be achieved if both teachers with disabilities and their abled counterparts are provided with professional development to enable them to appreciate the situation of the SWDs and adopt appropriate strategies to lessen their challenges.

Also, for SWDs in mainstream schools, their non-disabled peers should be conscientious in their interactions with SWDs for these students to be more proactive in sharing their learning needs with teachers and peers who can offer help (Rieger &

Rolfe, 2021). For SWDs to be able to express themselves freely, the learning or classroom environment should be more welcoming. To achieve this, positive collaboration should be encouraged among students. That is, SWDs in inclusive settings or in mainstream schools can work in project teams or alongside their peers during learning tasks. Teachers may need to take an active role in fostering collaboration among SWDs (Morris, 2002). This collaboration can extend to SWDs' interactions with teachers, parents, caregivers, and significant others. For example, Francis et al. (2018) have underscored that collaboration among students and their families, educators, and caregivers is essential for young adults with disabilities.

Focusing on the classroom aspects of empathetic design, it is the responsibility of school leaders and government officials in charge of education to install digital tools and assistive devices that enhance the capability of SWDs to learn (Staples et al., 2005). To ensure proper classroom engagement, teachers might need to continually monitor or assess the learning progress of SWDs to identify individual weaknesses and strengths to inform creative solutions to mitigate their weaknesses and enhance their strengths. That is, in the classroom setting, teachers have to apply personalized and adaptive learning methods to support the learning of SWDs (Moriña & Orozco, 2020a, 2020b).

Moreover, a supportive and disability-friendly learning environment should be created for SWDs in terms of architectural and instructional design (Braun & Naame, 2021). The ethos of the school should focus on promoting SWDs' accessibility to learning materials and special needs services, the emotional well-being of SWDs, and accommodating their needs.

In a generic sense, the principles of universal design for learning (UDL) which allow for multiple representations and expressions in learning should be applied in the shift toward a more empathetic approach in delivering education to SWDs (Heylighen & Dong, 2019; Izzo & Bauer, 2015). UDL's approach to learning is favorable for SWDs with different disabilities and learning needs. From a practical point of view, without judicious consideration of the four interrelated fundamental factors spelt out to know learner needs in the conceptual model, the next steps of design in education which include ideation and implementation may not be sufficiently achieved. This is because the learning materials and support offered to students may not be what they want or need. Future researchers should apply a design thinking perspective to test the proposed model in this chapter using empirical data.

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Chapter 10
Technology-Enhanced Mulsemedia Learning (TEML) Through Design for Learners with Dyslexia for Enhancing the Quality of Experience (QoE)

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Abstract Design Thinking (DT) is a successful problem-solving approach used in education to address ill-defined problems. Traditional learning faces the challenge of static e-learning content, but enhanced e-content, such as multimedia, has improved the learning process. Recent research work suggests that Multi-sensorial Media mulsemedia content, which integrates haptic, olfactory, and gustatory to the traditional audiovisual multimedia content, enhances the Quality of Experience (QoE) by engaging multiple senses. This chapter proposes Technology-Enhanced Mulsemedia Learning (TEML) through design for learners with dyslexia to improve QoE and obtain twenty-first-century learning skills such as cognitive, productivity, social-cultural, metacognitive, and technological dimensions. This chapter also proposes a mulsemedia test bed with the help of IoT devices, which is cost-effective and can be adapted in future studies through design techniques and focuses on STEM (Science, Technology, Engineering, and Mathematics) subjects for dyslexia learners. Moreover, this chapter examines various questions related to mulsemedia's implementation, including the necessary devices and challenges and opportunities presented

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by the approach and argues that integrating mulsemedia through design can transform the learning process, especially for learners with dyslexia, and concludes by highlighting the potential for future research in this area.

10.1 Introduction

The concept of Quality of Experience (QoE) holds substantial significance across diverse domains, with education being no exception. Within the realm of learning, QoE pertains to the degree of satisfaction and engagement that learners encounter throughout their educational journey (Schmidt & Allsup, 2019). This holistic notion encompasses a multitude of factors, encompassing the efficacy of the instructional approach, the caliber of learning resources, the alignment of content with learners' requisites, as well as the depth of interactivity, and the quality of feedback delivered throughout the learning process (Zurbriggen, 2018).

The QoE in learning is critical for ensuring that learners achieve their learning objectives effectively and efficiently. It is a measure of the effectiveness of the learning experience, and it can impact learners' motivation, engagement, and retention of knowledge. As such, educators and instructional designers need to pay close attention to the QoE in their learning programs and strategies to ensure that learners have the best possible experience. Since QoE is an essential aspect of learning that involves creating an effective and engaging learning experience for learners, it is no surprise that in recent years, the use of mulsemedia in education has become increasingly popular as it has the potential to significantly enhance the QoE in learning (Tal et al., 2020).

Mulsemedia refers to the integration of different media types that engage more than three human senses into a single presentation environment (Ghinea et al., 2011) (See Fig. 10.1). The use of mulsemedia in education can significantly enhance the QoE in learning by providing learners with an immersive and engaging learning experience that caters to different learning styles (Ljubojevic et al., 2014; Bi et al., 2018; Tal et al., 2020). One of the key benefits of using mulsemedia in education is that it allows for the creation of highly interactive and personalized learning experiences (Bi et al., 2018; Tal et al., 2020). For example, a mulsemedia-based learning environment can include interactive simulations, animations, and videos, which can help learners better understand complex concepts and retain information more effectively. Plus, mulsemedia-based learning environments can be designed to cater to different learning styles, such as visual, auditory, and kinesthetic learners (Ljubojevic et al., 2014; Bi et al., 2018; Tal et al., 2020). This can help to enhance the QoE in learning by providing learners with a personalized and engaging learning experience that caters to their specific needs. This said the use of mulsemedia in education has the potential to significantly enhance the QoE in learning by providing learners with an immersive, interactive, and personalized learning experience.

However, it is still a subject of study how mulsemedia can improve QoE for Educational purposes when dealing with Learning disabilities (Elsharif et al., 2020;

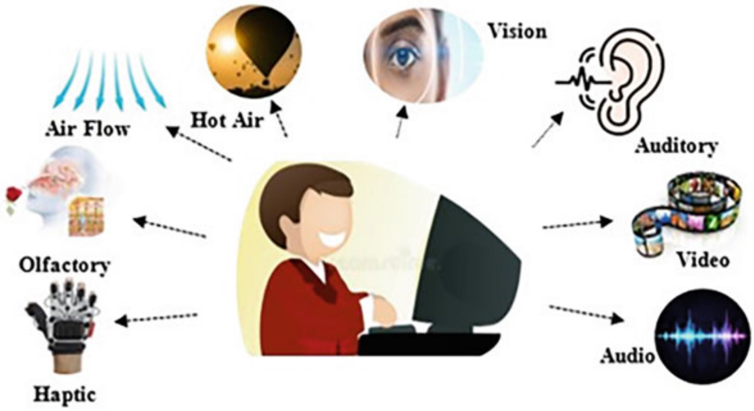

Fig. 10.1 Mulsemedia components

Fig. 10.2 Haptic devices

Ghinea et al., 2011). Since mulsemedia significantly improves the QoE in education, learners with learning disabilities can also benefit from this. Learning disabilities, such as dyslexia, dysgraphia, and Attention-deficit/hyperactivity disorder (ADHD), can make it challenging for learners to engage with traditional learning methods, such as reading and writing. However, mulsemedia-based learning environments can provide an effective and engaging learning experience for learners with learning disabilities.

One of the key benefits of using mulsemedia in education for learners with learning disabilities is that it can provide alternative means of presenting information (Tal et al., 2020). For example, a learner with dyslexia may struggle with reading text-based materials. Still, a mulsemedia-based learning environment can present the same information using images, videos, and audio, which can be more accessible for the learner. Moreover, mulsemedia-based learning environments can be designed to accommodate different learning styles and needs, which can significantly improve the QoE in learning for learners with learning disabilities. For example, a learner with ADHD may benefit from a highly interactive learning environment with frequent breaks and visual cues to help them stay engaged and focused (Hutson &

Hutson, 2023). Another advantage of using mulsemedia in education for learners with learning disabilities is that it can provide a more engaging and motivating learning experience. Many learners with learning disabilities may struggle with motivation due to their learning challenges (Silva et al., 2021a, 2021b). However, mulsemedia-based learning environments can provide an immersive and interactive learning experience that can significantly increase motivation and engagement. Furthermore, mulsemedia-based learning environments can provide immediate feedback, which can help learners with learning disabilities monitor their progress and identify areas where they need to improve. This can be particularly beneficial for learners with ADHD, who may struggle with self-monitoring and self-regulation (Silva et al., 2021a, 2021b).

That said, Learning Design (LD) can play a crucial role in creating effective mulsemedia-based learning environments for learners with learning disabilities. Designers can use the principles of Universal Design for Learning (UDL) to ensure that the learning environment is accessible, engaging, and effective for learners with diverse learning needs and styles (Rose & Meyer, 2002). UDL principles advocate for providing multiple means of representation, expression, and engagement to accommodate different learners' needs (CAST, 2018). For example, designers can use captions, transcripts, and audio descriptions to make multimedia content accessible for learners with hearing impairments and expand it with mulsemedia to improve attention and focus with scent deliverers or haptic devices. They can also use interactive features, such as quizzes and simulations, to provide learners with different ways of engaging with the content and expressing their knowledge. Furthermore, designers can use adaptive technologies, such as personalized learning algorithms and assistive technologies, to provide tailored learning experiences that meet learners' specific needs (Beetham & Sharpe, 2013).

An additional pivotal component involves the integration of Design Thinking (DT), as underscored by recent research (Koh et al., 2015; Lor, 2017). This methodology encompasses a problem-solving approach that places emphasis on creativity, empathy, and collaborative efforts to devise innovative solutions for complex challenges (Brown, 2008). Operating as a human-centered design framework, it commences with a profound comprehension of the requisites, viewpoints, and incentives of the individuals who will ultimately utilize the proposed solution. In the context of education, Design Thinking holds particular significance, as it equips educators and designers with the tools to construct compelling and efficacious learning experiences aligned with learners' objectives and needs (Lazo-Amado et al., 2023). Consequently, comprehending the role of multimedia becomes evident, as it emerges as a catalyst in enhancing the QoE for learners with learning disabilities. Through its provision of alternative modes of information presentation, catering to diverse learning styles and requirements, amplifying motivation and engagement, and furnishing immediate feedback (Koh et al., 2015; Kelly et al., 2013), multimedia plays a pivotal role in augmenting the educational landscape.

The organization of this chapter unfolds as follows: Sect. 10.2 will delve into the exposition of pertinent prior research and elucidate the driving factors behind our pursuit. Sections 10.3 and 10.4 will engage in a comprehensive exploration of

Learning Content and Learning Disabilities, respectively. Moving forward, Sect. 10.5 will shed light on the available devices for implementation. Subsequently, Sect. 10.6 will expound upon the essence of Design Thinking and its application in the integration of mulsemedia to enrich conventional multimedia content. The subsequent focus, Sect. 10.7, will lay out the proposed TEML (Technology-Enhanced Multimedia Learning) framework along with the outcomes of the user study. Tackling the intricacies, Sect. 10.8 will address both challenges and prospects that lie ahead. Finally, culminating the discourse, Sect. 10.9 will unveil our concluding remarks.

10.2 Motivation and Related Work

Learning is an important stage for gaining more insight into the world around them and understanding different perspectives of things for retaining the concept for the long term. Moreover, the QoE, or quality of service (QoS) plays a vital role in the fulfillment of the learner's expectation with respect to the utility and enjoyment of the application. For this, multisensory learning theories stimulate the various sensory channels to reinforce the learning process. Hence, mulsemedia offers an enriched learning encounter, particularly advantageous for learners with dyslexia. Previous studies indicate that the incorporation of diverse sensory signals assists in diminishing cognitive burden and enhancing the learning journey (Broadbent et al., 2018). Furthermore, such an approach holds promise for individuals with an array of conditions, encompassing sensory or cognitive impairments.

10.2.1 Motivation

To begin with, the genesis of the proposed concept finds its roots in the realm of education, catalyzed by the unprecedented rise of e-learning content in response to the COVID-19 pandemic. Moreover, it is driven by the aspiration to enrich e-learning content by seamlessly integrating multimedia elements, thereby elevating the entire pedagogical process. This impetus is further bolstered by insights from neuroscience, which accentuate the potential for enhanced learning outcomes that endure over time. This approach facilitates the retention of concepts in the long run while engendering an immersive learning journey, accomplished through the judicious use of mulsemedia resources to recreate real-world scenarios.

Multimedia helps to expand the possibility of real-world senses, which are involved in the research area of Multi-sensorial Media (Mulsemedia). It includes the combination of traditional multimedia (audio, video, text, images, etc.,) with other human senses (referred to as non-traditional media), such as olfactory, haptic (water jet, vibration, temperature, and generate airflow), gustatory, and so on. Previously published notable works (Stančin et al., 2020; Tal et al., 2016; Zou et al., 2017) show that the combination of both multimedia and other senses helps to enhance the learner's QoE. Here, DT helps the educator to solve the problem in e-learning materials through the Mulsemedia approach.

10.2.2 Related Work

In order to create user-centered experiences, interdisciplinary teams work together under the principles of design thinking, which is an innovative, creative, and human-centered method and mindset. It has been applied in many areas such as business, engineering, and technology and more recently applied in education because of its ability to advance creativity and innovation through an empathetic, flexible, and iterative approach. Furthermore, it helps to develop twenty-first-century learning skills such as cognitive, productivity, social-cultural, metacognitive, and technological dimensions.

The work presented by Yedra et al. (2021) evaluates the design thinking-based playful application concept for learning with disabled children such as dyslexia. This problem occurs due to the way that the brain incorporates and processes information. Following that, Campos et al. (2019) presented gamification using a design thinking approach to understanding the learner's difficulties. Based on observation, the author designed a paper-based prototype as output and discussed the contribution of each group through the iterative process for increasing the learning experience. Lazo-Amado et al. (2023) presented a mobile application for children with dyslexia for primary education using augmented reality. This approach helped to solve the group work and decision-making problem of disabled children. Goodman et al. (2020) have introduced LaMPost, a natural language-based larger language model (LLM) for overcoming the challenges in writing experienced by people with dyslexia, which also addresses the challenges in new spelling, grammar, and word retrieval technologies. This method was assessed with 19 adults with dyslexia. Clemente et al. (2016) presented a toolkit for product design and development courses based on design thinking concepts. This tool was aimed at promoting students' creative and critical thinking skills. Furthermore, these results show that students' critical thinking is improved based on the didactic intervention integrated method.

The work presented by Zou et al. (2017) utilizes mulsemedia to enhance the QoE for learners. The authors developed a test bed to deliver video content enhanced with haptic, airflow, and olfaction effects. The experimental results demonstrate that mulsemedia enhances their learning experiences. Moreover, Guedes (2018) designed a multisensorial book combined with enhanced e-content and multisensorial media to improve the learning process. A prototype was developed with audio, haptic, and olfactory effects, which method gave promising results and opened new avenues for future research. Following that, Silva et al., (2021a, 2021b) created Mbook, a tool for presenting multisensorial books. This book is different from the normal traditional book, which is that mulsemedia devices are synchronized by capturing the reading position using an eye-tracker. This approach was experimented with by students aged 13 to 19 years. The main aim of this work is to improve the children's learning experience while reading books. Nawandar et al. (2018) have presented an IoT-based multisensory network to assist people with visual disabilities. The authors designed their kit in an easy way and cost-effective as well as GPS-assisted outdoor navigation with RFID technology. Koukourikos et al. (2015) have introduced a low-cost haptic device that integrated tactile and audio to provide a multisensory effect for blind people. This was experimented with for 19 years to 46 years. Mon et al. (2019) have designed virtual edutainment environments for visually impaired users based on olfactory, audio, and haptic-based 3D applications. The author of this paper proved that those different kinds of applications are more attractive and efficient for visually impaired learners.

10.3 Limitations in E-Content

In recent years, e-learning, referred to as "e-content" or "electronic content", has become an effective method for students to learn concepts from anywhere in the world (Stecuła & Wolniak, 2022). However, individuals may encounter challenges in grasping information due to a variety of variables such as differences in learning styles, learning impairments, difficulties with attention and focus, memory problems, anxiety or stress, and a lack of desire or enthusiasm (Rose et al., 2002). Furthermore, certain forms of e-content, such as static text documents or online articles, might lack interactivity and engagement compared to traditional teaching methods. Although interactive multimedia within e-content assists learners in understanding concepts, it may not provide fully immersive learning experiences, as it typically focuses on only two senses: sight and hearing (Anene et al., 2014; Mayer, 2009). In real-time environments, humans perceive information through more than just two senses. Addressing these gaps by incorporating multimedia-based interactive content can be efficient for learners to interpret both the content and context, as supported by existing multimedia research (Hutson & Hutson, 2023). However, the inclusion of multisensorial media in e-content helps learners retain concepts for a longer time compared to conventional e-learning (Tal et al., 2020). Additionally, several factors significantly impact the effectiveness of e-content in learning.

10.3.1 Low Level of Student Engagement in the Classroom

A low-level degree of student engagement within the classroom context pertains to learners who exhibit limited involvement in the learning journey. These individuals may display signs of indifference, boredom, or distraction during instructional sessions, refraining from active participation in class discussions or exercises (Truong, 2016). This lack of robust engagement among students can stem from diverse factors, encompassing a disinterest in the subject matter, challenges in comprehending the content, a feeling of disconnect from both the teacher and peers, or external influences such as personal preoccupations and distractions.

Insufficient student engagement can adversely affect both the students and the teachers involved. Students might encounter difficulties in retaining knowledge and achieving subpar outcomes in assessments or assignments. Concurrently, a dearth of active participation can lead to teachers experiencing frustration or a sense of demoralization, impeding their ability to deliver effective instruction.

10.3.2 Lack of Research on Methods of Learning and Teaching

The lack of research on learning and teaching methods refers to a scarcity of scientific studies and data on the most effective teaching and learning tactics (Hosseindoost et al., 2022). Because of this research gap, educators may find it challenging to make educated judgments about how to best assist their students' academic advancement. The limited research could be attributed to a few problems, including a lack of funding or resources, difficulties in conducting studies in real-world classroom settings, and the complexity of the learning process itself. Also, there may be a concentration on short-term outcomes, such as test scores, rather than a long-term assessment of the influence of teaching methods on the lives of students.

10.3.3 Lack of Interest and Relevant Content

The lack of interest and relevant content refers to a situation where students feel disengaged from the material being taught in the classroom. This detachment can be attributed to several factors, including a perceived disparity between the content and their personal interests or real-life encounters, complexities in comprehending the material, or a lack of engagement from the instructor (Anene et al., 2014). When this disconnect occurs, students often grapple with maintaining focus and motivation, resulting in diminished academic performance and an unfavorable disposition toward learning. Concurrently, teachers encounter challenges in delivering effective instruction when students are disengaged, perpetuating a cycle of frustration and dwindling interest.

10.4 Learning Disability and STEM Subjects

A learning disability is a neurological illness that hinders a person's capacity to properly acquire, process, store, or generate knowledge. It can have an influence on a variety of academic areas, including reading, writing, math, and communication abilities (Lam et al., 2008; Louick & Muenks, 2022). Moreover, learning difficulties are frequently identified in childhood and can last into adulthood. Common forms of learning disorders include dyslexia (reading trouble), dyscalculia (math difficulties), and dysgraphia (difficulty with writing). Additional disorders that might affect learning include ADHD and autism spectrum disorder (ASD) (Thapliyal & Ahuja, 2023).

Among all learning disabilities, dyslexia plays an important role. It is a neurological condition that affects a person's ability to read, write, spell, and, in some cases, talk (Hall et al., 2023). It is frequently distinguished by difficulties in phonological processing, or the capability to detect and control sound in language. Dyslexics may also struggle with word recognition, reading fluency, and understanding. Detecting dyslexia in an individual often requires a full evaluation undertaken by a certified expert, such as a psychologist, neuropsychologist, or educational specialist (Hall et al., 2023).

There are several sorts of evaluations that can be implemented to evaluate various areas of a person's talents and performance. The following are some examples of common sorts of evaluations: Achievement tests, Cognitive tests, Neuropsychological tests, Personality tests, Behavioral assessments, Diagnostic tests, and Aptitude tests (Andresen & Monsrud, 2022). Many elements, including the individual's age, developmental stage, and others, will determine the sort of assessment that is employed to meet the evaluation's unique demands and objectives (Andresen & Monsrud, 2022).

Learning difficulties can be accommodated in STEM subjects, which concentrate on science, technology, engineering, and mathematics. Students who have disabilities often focus less on STEM subjects (Asghar et al., 2017; Schreffler et al., 2019). More specially, science content can pose significant barriers to understanding concepts with disabilities or special learning needs (Israel et al., 2013; Klimaitis & Mullen, 2021).

Moreover, drawing insights from the existing body of literature, Design Thinking emerges as a noteworthy remedy catering to students with disabilities in the realm of education (Yedra et al., 2021; Goodman et al., 2022; Clemente et al., 2016). Building upon these foundations, this chapter pioneers the introduction of a mulsemedia framework tailored to learners with dyslexia, skillfully intertwining the principles of design and STEM subjects.

10.5 Mulsemedia Devices and Their Uses

The domain of mulsemedia presents a realm rich with diverse opportunities. Nevertheless, the optimal methods of delivering mulsemedia content remain an area under active investigation. Mulsemedia devices hold the transformative potential to reshape our engagement and interaction with digital media across an array of domains, spanning education, entertainment, healthcare, and rehabilitation. By concurrently engaging multiple senses, these devices have the capacity to engender heightened immersion and captivation. This, in turn, holds the promise of augmenting learning achievements, amplifying motivation, and elevating the overall quality of life for individuals grappling with disabilities.

Nonetheless, the integration of mulsemedia devices into practice introduces a host of challenges that warrant careful consideration to unlock their full potential. Foremost among these challenges is the elevated cost associated with the development and deployment of mulsemedia systems, which often surpasses that of traditional media systems by a considerable margin (Saleme et al., 2019). Furthermore, the utilization of multiple sensory modalities necessitates meticulous attention to design and user experience, ensuring harmonious synchronization without overwhelming the user (Silveira et al., 2023).

Another obstacle lies in aligning Mulsemedia devices with existing infrastructure and hardware, along with the requirement for specialized software and hardware provisions (Saleme et al., 2015). The creation of mulsemedia content also demands access to specialized expertise and resources, encompassing multimedia professionals and designers, thereby potentially limiting the widespread availability and accessibility of such content. Moreover, the inclusion of olfactory and gustatory elements within mulsemedia devices is a relatively nascent endeavor, with the development of fitting hardware and software to support these facets still in its infancy.

Lastly, ethical and safety considerations related to the use of mulsemedia devices, particularly in healthcare and rehabilitation, need to be considered. Despite these challenges, the potential benefits of mulsemedia devices are significant, and ongoing research and development are expected to address these challenges and pave the way for the widespread adoption of mulsemedia devices in various applications.

That said, there are some mulsemedia devices that can be highlighted for this work. For this, we are going to split the devices into three different categories: haptic, gustatory, and olfactory.

10.5.1 Haptic Devices

Haptic devices are hardware devices that provide users with tactile feedback by simulating the sense of touch (Kim et al., 2017; Lee et al., 2021; Saber-Sheikh et al., 2019). These devices can be used to enhance the user experience of various applications, including virtual reality, gaming, and healthcare. Haptic devices typically include sensors that detect user input and actuators that generate tactile feedback, such as vibrations, pressure, or motion. The feedback can be programmed to simulate different sensations, such as texture, weight, or temperature, and can be used to provide users with a more immersive and interactive experience. In virtual reality, haptic devices can be used to simulate the sensation of touching and manipulating virtual objects, improving the sense of presence and realism. In gaming, haptic devices can provide users with feedback that enhances the gameplay experience, such as simulating the recoil of a weapon or the sensation of driving on different surfaces. In healthcare, haptic devices can be used for rehabilitation, allowing patients to perform exercises that require tactile feedback, such as gripping or reaching. The development of haptic devices has opened new possibilities for creating more immersive and interactive applications that can enhance the user experience and improve outcomes in various fields.

Examples of these devices are gloves to simulate touch, controllers with vibration (Adilkhanov et al., 2022), fans to simulate wind and thermal effects (Silveira et al., 2023), etc. Haptic devices can be grounded devices (not wearable), which are divided into graspable and touchable systems; Hand-held devices ("partially" wearable), distinguished based on the type of actuation (direct or indirect) with respect to the user's limb and wearable devices, further classified into exoskeletons and gloves, finger-worn devices, and arm-worn devices (Obrist et al., 2014). Haptic devices are becoming increasingly popular in education to enhance learning outcomes. By providing students with a tactile and interactive experience, haptic devices can help learners better understand complex concepts and retain information more effectively. For example, haptic feedback can be used in simulations to help students feel the forces involved in a physics experiment or to provide realistic sensations in medical training simulations (Liu et al., 2017). Additionally, haptic devices can be used to improve accessibility for learners with visual or auditory impairments, by providing alternative sensory inputs (Jones et al., 2014). As technology continues to evolve, haptic devices are likely to play an increasingly important role in education, helping learners to engage with the material in new and innovative ways.

10.5.2 Gustatory Devices

Gustatory devices, also known as taste interfaces, are a type of sensory feedback device that provides a taste sensation to the user. These devices work by stimulating the taste buds on the tongue, either using electrical or chemical stimulation. Gustatory devices have a range of potential applications, such as enhancing the sensory experience of food and beverages, providing sensory feedback in virtual and augmented reality applications, and assisting individuals with taste impairments or dysfunctions. Research on gustatory devices is still in the early stages, and there are currently few commercial products available on the market (Saleme et al., 2019). However, there is growing interest in this area, with researchers exploring new ways to create and refine gustatory devices and exploring their potential applications.

According to (Saleme et al., 2019), in comparison to other stimuli, chemical senses have not been fully explored, and there is still little data on how they can be used in human–computer interfaces. Creating authentic taste experiences is challenging because it requires stimulating all senses, including taste, smell, and the trigeminal nerve. While the tongue can detect the five basic tastes, other taste sensations, such as heat and creaminess, are detected by the trigeminal sense (Saleme et al., 2019). Digital setups can modify taste and bring interesting insights (Obrist et al., 2014), as different tastes have varying effects on cognitive activities and decision-making. Sour tastes promote slower, more reasoned decision-making, while sweet and bitter tastes lead to quicker, instinctual decision-making. Systems that stimulate taste directly or modify taste through other senses can be included in multisensory systems.

Examples of these devices are Lollio (Murer et al., 2013) and Digital Lollipop (Ranasinghe & Do, 2017), which simulate sour and sweet via an outlet that pumps flavors to the lollipop and sour, salty, bitter, and sweet via electrodes, respectively. Some gustatory devices also don't make use of flavor pumps or electrodes, but do it via visual stimuli, like the Meta Cookie (Guimarães et al., 2022) which uses visual stimulation to promote different tastes. This is an example of how multiple senses can be used to achieve different objectives.

While gustatory devices, or devices that simulate taste, are not commonly used in education, they have shown potential in certain applications. One example is in language learning, where a gustatory device could be used to provide students with the opportunity to taste and identify foods from different cultures, while simultaneously learning the corresponding vocabulary. Additionally, a gustatory device could be used in science classes to demonstrate chemical reactions that produce different tastes or to teach about the different tastes associated with the various regions of the tongue (Guedes, 2018).

10.5.3 Olfactory Devices

Olfactory devices, also known as smell interfaces or scent devices, are a type of sensory feedback device that provides a scent or smell sensation to the user. These devices work by emitting scents or odors into the surrounding air, either using chemical or mechanical means. Olfactory devices have a range of potential applications, such as enhancing the sensory experience in entertainment, gaming, and virtual reality applications, providing sensory feedback in medical or therapeutic contexts, and assisting individuals with smell impairments or dysfunctions. Research on olfactory devices is still in the early stages, and there are currently few commercial products available on the market (Murray et al., 2017). However, there is growing interest in this, with researchers exploring new ways to create and refine olfactory devices and exploring their potential applications.

Examples of these devices are ExHalia and Vortex Active, which use fans to dissipate the scent in the ambient. Due to the evolution of virtual reality, Mounted Head Olfactory devices are also being developed so the olfactory stimuli are dissipated directly to the nose of the user, such as the work of (Narumi et al., (2011) and Alkasasbeh et al., 2020).

Olfactory devices can also play a role related to some haptic stimuli, like the use of scents to give the sensation of temperature change (Brooks et al., 2020) via the trigeminal nerve. The trigeminal nerve is a sensory organ responsible for detecting sensations such as temperature, pressure, and pain in the face. In addition to detecting temperature, the trigeminal system can also create the illusion of temperature through the activation of chemoreceptors. Chemoreceptors are sensitive to chemicals such as capsaicin (found in hot peppers) and menthol (found in mint) (Brooks et al., 2020). When these chemicals meet the trigeminal nerve, they can activate the thermoreceptors, creating the sensation of warmth or coldness even if there is no actual change in temperature. For example, capsaicin activates the thermoreceptors in such a way that we feel a burning sensation, even though the temperature of the food itself may not be particularly hot (Brooks et al., 2020).

Incorporating olfactory devices also presents the potential to enrich the landscape of learning encounters. The sense of smell shares an intimate connection with memory, rendering olfactory devices in education a tool capable of enhancing students' information retention and recall proficiency (Garcia-Ruiz et al., 2021). To illustrate, within a history class, the waft of a distinct perfume or spice might serve as a conduit, transporting students to a different era and location, thereby facilitating a deeper grasp of historical events and their contextual intricacies. Similarly, in a biology class, the utilization of olfactory devices could emulate the aroma of specific chemicals or organisms, fostering a heightened comprehension and recollection of the attributes and traits associated with these substances.

10.6 Design Thinking in Technology-Enhanced Mulsemedia Learning

Enhance the learning experience using design thinking with mulsemedia. The design thinking process typically involves five stages: empathize, define, ideate, prototype, and test (Meinel et al., 2009; Basham & Marino, 2013) (See Fig. 10.3).

(1) During the empathize stage, designers immerse themselves in the learners' world, comprehending their needs, motivations, and obstacles through observation and interaction. This process cultivates empathy and facilitates an in-depth grasp of the learners' perspectives and encounters. By commencing with the empathize stage, designers foster a thorough understanding of learners' requirements, challenges, and motivations. This comprehension serves as the bedrock

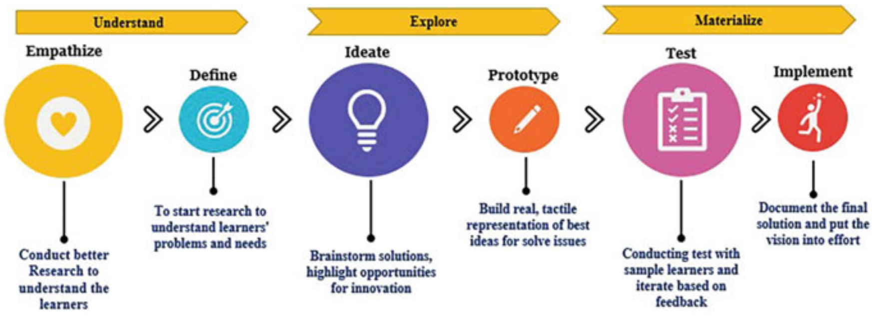

Fig. 10.3 Design Thinking Process

for crafting tailored mulsemedia experiences that align with learners' objectives, thus ensuring an engaging and effective learning journey (Meinel et al., 2009).

(2) In the defining stage, designers use insights gained from the empathize stage to define the problem they are trying to solve. They formulate a problem statement that captures the learners' needs and goals and guides the ideation process. For example, if learners with dyslexia struggle with reading text-based materials, the problem statement might be "How might we create a mulsemedia-based learning experience that presents information using stimuli beyond images, videos, and audio to make it more accessible and engaging for learners with dyslexia?

(3) In the ideate stage, designers generate a wide range of ideas and potential solutions to the problem. They encourage creativity and brainstorming to generate a diverse range of solutions.

(4) In the prototype stage, designers create low-fidelity prototypes of their ideas to test and refine. Prototyping allows designers to quickly test and iterate their ideas, gather feedback, and refine their solutions. They can use iterative testing and feedback to refine their mulsemedia-based learning experience until it meets the learners' needs and goals.

(5) Finally, in the test stage, designers test their prototypes with learners to gather feedback and evaluate their effectiveness. This allows designers to refine their solutions and make any necessary changes to improve their effectiveness and impact.

As said before, one of the key benefits of using mulsemedia in education is that it can provide an alternative means of presenting information (Saleme et al., 2020). For learners with learning disabilities, such as dyslexia or ADHD, mulsemedia-based learning environments can present information using stimuli like smells and touch which can be more accessible and engaging than standard multimedia content. Furthermore, mulsemedia-based learning environments can be designed to accommodate different learning styles and needs, which can significantly improve the quality of learning for learners with learning disabilities.

In summary, by combining design thinking with mulsemedia, educators, and designers can create highly engaging and effective learning experiences that meet the needs and goals of learners. These experiences can be tailored to accommodate different learning styles and needs, making them accessible and effective for learners with learning disabilities.

10.7 Proposed TEML for Learners with Dyslexia

The proposed TEML web portal utilizes both multimedia and mulsemedia technology, IoT devices, which creates an engaging and immersive learning experience. The system is designed to provide learners with a realistic and immersive learning experience by incorporating STEM content along with multisensory effects, such as airflow, olfaction, and vibration. The content was selected from science and physics backgrounds to engage learners with STEM subjects. Finally, self-feedback is given to analyze the QoE of learners. The humidifiers provide learners with a more realistic and engaging experience, as they can feel and smell the environment when they are learning about rosemary content. The addition of airflow and vibration effects allows students to experience the content of thunder and lightning through tactile feedback, making it more immersive. The TEML web portal includes audio and multimedia effects that are synchronized with the airflow, olfactory, and haptic feedback provided by the IoT devices. This allows learners to have an immersive learning experience while hearing STEM-related audio content. Figure 10.4 shows the first proposed prototype of TEML for learners with disabilities.

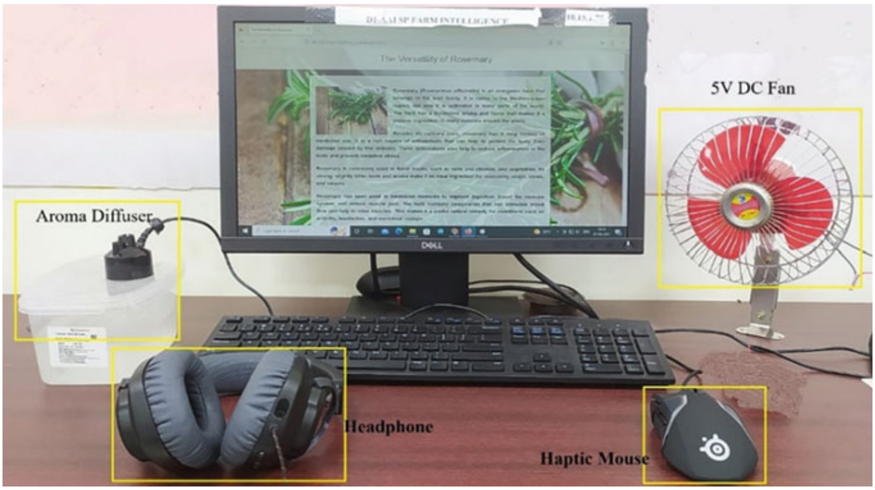

Fig. 10.4 Proposed mulsemedia testbed

The working principle of the proposed Internet of Things (IoT)-based mulsemedia learning system involves the integration of several components to create a multisensory learning environment. Here, the STEM content is selected and developed into a multimedia format such as images, audio, and interactive activities. These multimedia elements are then synchronized with the IoT devices, such as the cooling fans, and humidifiers for olfaction and haptics for vibration. The length of the audio is 3 to 4 min. The cooling fans are used to provide airflow that simulates the environment being learned about physics content (thunder and lightning). The humidifiers are used to provide olfaction to enhance the learning experience, particularly in subjects such as biology, where olfaction is an essential aspect. The Arduino microcontroller serves as the central control unit that controls the IoT devices, synchronizes the multimedia elements, and manages the sensory feedback. The website that accompanies the system is used to provide remote access to the multisensory learning environment. The website includes multimedia elements such as audio, images, and interactive activities, which are synchronized with IoT devices to provide a multisensory learning experience to students. The system's working principle involves the synchronization of multimedia elements with IoT devices to create a multisensory learning environment that engages students in an immersive experience. The use of haptics and IoT devices provides tactile feedback that enhances the learning experience, making it more engaging and realistic.

The Web portal is designed to offer learners a convenient and immersive platform to access educational resources in STEM concepts. Figure 10.5 shows the home page of the Multimedia web portal, where this web portal consists of both biology content and physics content. The multimedia web portal is built on HTML, CSS, and PHP techniques. It is leveraging the power of HTML and CSS to create a responsive and user-friendly interface. The portal is designed to provide a seamless experience to users across devices, including desktops and laptops. The content is organized into modules, which are easily accessible through simple Buttons. Each STEM module contains multimedia content, including text, images, and audio, that is synchronized to provide an engaging and immersive learning experience.

The integration of audio with e-learning content has several benefits. Audio provides an alternative way to consume content, particularly for learners who prefer auditory learning. It also helps learners retain information better as it reinforces the visual and textual content. Additionally, audio can be used to provide feedback and guidance, creating a more interactive and personalized learning experience. Figures 10.6 and 10.7 show STEM content using the mulsemedia effects, which consist of audio, Multisensory effects, and QoS assessment questions. The addition of audio can further improve the effectiveness of the interface by allowing learners to hear the information as well as read or see it. After the audio content finishes, learners are directed to an online assessment to test their understanding of the material. This type of online assessment allows for immediate feedback and provides learners with a better understanding of their knowledge gaps. The e-learning content for this research focuses on rosemary, and the presence of multimedia is used to enhance the learning experience. When the mulsemedia test bed is triggered by an Arduino, the rosemary essence is released, adding a sensory dimension to the learning experience. This can

Fig. 10.5 Home Page of TEML

help learners better understand and retain the information by engaging their sense of smell. In addition, while learning thunder and lightning effects airflow and vibration effects are given to the learner to feel audio content in a realistic environment. The duration of the audio content is 3 to 4 min. The synchronization works when the rosemary audio is playing, while the olfactory component turns the smell on and off automatically every 30 s. Similarly, it works on airflow and vibration in physics content.

10.8 Challenges and Opportunities in TEML

Technology-enhanced mulsemedia learning refers to the use of mulsemedia tools and technologies to create engaging and interactive learning experiences for students. While this approach offers many opportunities for enhancing learning, as presented below, it also presents several challenges in different fields (Ghinea et al., 2014).

As stated by Ghinea et al. (2014), mulsemedia is not just the sum of multiple multisensory stimuli, but also the understanding of how each stimulus works:

> [...] mulsemedia sensory media perception is not something that just happens. Perception is a complex combination of steps that combine bottom-up (sensory processing) and top-down (cognitive reasoning) processes, which result in the appreciation of the media information and the interpretation of its meaning in the context of existing semantic and episodic knowledge. Sensory processing is well understood. The process of understanding how knowledge impacts mulsemedia media interpretation, perception, and acceptance, however, is an exciting area of research.

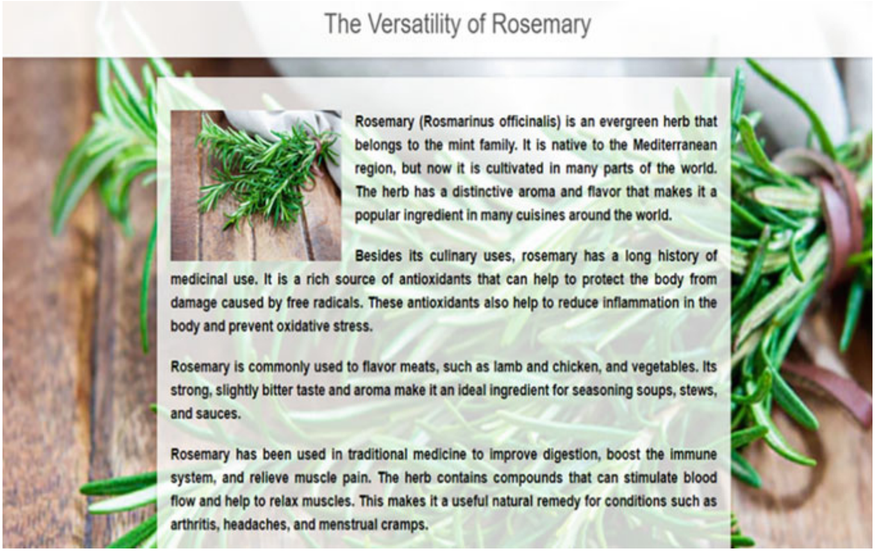

Fig. 10.6 Rosemary content (Olfactory)

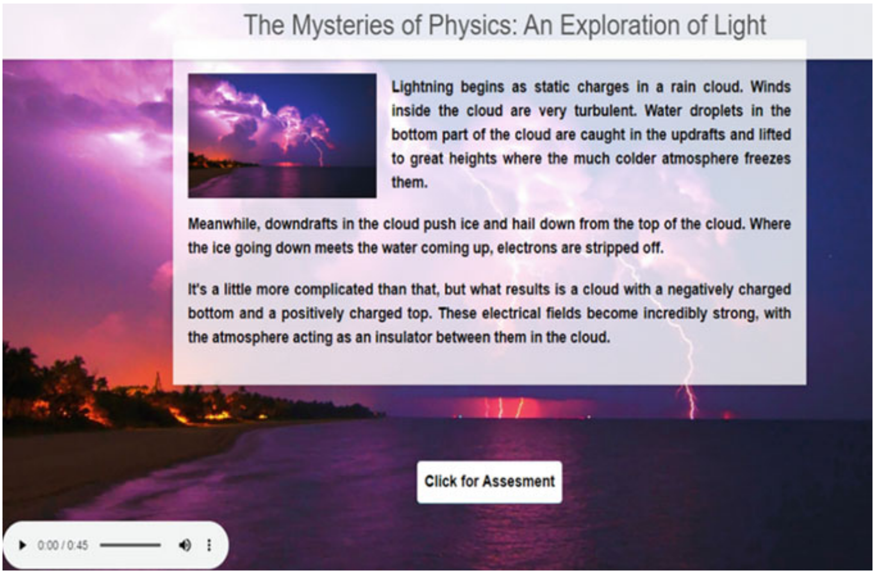

Fig. 10.7 Thunder and lighting content (Haptic and Airflow)

So how to employ mulsemedia elements in teaching is still a field to be explored. Teachers must be knowledgeable about the latest tools and technologies and must be able to effectively integrate them into their curriculum. This requires ongoing professional development and training, which can be time-consuming and costly. Another challenge is the potential for technology to distract students and hinder their learning.

However, technology-enhanced mulsemedia learning also presents many opportunities for enhancing the learning experience. It allows for the creation of engaging and interactive learning experiences that can help students develop critical thinking skills and improve their understanding of complex concepts. Additionally, technology-enhanced mulsemedia learning can help promote collaboration and communication among students, enabling them to work together on projects and share ideas. It can also help teachers to better assess student learning and provide timely feedback to support their growth. Overall, while there are challenges in implementing technology-enhanced mulsemedia learning, the opportunities it presents for improving the learning experience make it a valuable tool for educators to consider.

10.9 Conclusion and Future Work

In conclusion, mulsemedia stands as a promising technology for learners with disabilities, offering an avenue to grasp concepts within the context of a real-world environment. As of our current knowledge, no existing studies have addressed the challenge of unengaging e-content through a mulsemedia-infused design approach. In this chapter, we introduced the mulsemedia framework to enrich the QoE for learners with disabilities, all while embracing a design-oriented methodology. This approach not only contributes to enhancing QoE but also facilitates the cultivation of twenty-first-century learning skills, spanning cognitive, productivity, social-cultural, metacognitive, and technological dimensions.

Furthermore, the chapter expounded upon key concepts, including the significance of QoE and QoS, delineating how mulsemedia serves to elevate these aspects. The exploration extended to encompass the realm of learning disabilities and the role of mulsemedia in solidifying long-term concept retention. Additionally, the integration of mulsemedia into the learning journey of individuals with dyslexia was expounded upon through a design-centered strategy.

Notably, the chapter also delved into prevalent challenges encountered during the implementation of mulsemedia devices, alongside the array of opportunities this technology presents. In the forthcoming period, this approach will be put to the test with dyslexia learners, and their resulting QoE will be meticulously analyzed. In tandem, the proposed system underwent experimentation involving 10 participants, gauging their experiences and perceptions while learning within this framework. Participants corroborated that the infusion of multimedia effects into the learning process leaves a markedly impactful impression.

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Chapter 11
Design of Future Classrooms: A Review of Learning Space Designs and Learning Methods

Boulus Shehata

Abstract The design of future classrooms has become a topic of great priority as technology and pedagogy continue to evolve. However, there is a lack of consensus on the different designs of future classrooms that can support diverse learning needs and styles. Therefore, this rapid review explores the various learning space designs and learning methods, aiming to provide insights into the development of effective learning environments that promote student engagement and success. The methodology section presents the search strategy, selection criteria, and data extraction and analysis. Key findings indicate various physical (e.g. library, laboratory) and digital learning environments (e.g. social media platforms), and several teaching and learning approaches, such as teacher-led, student-centered, collaborative, or technology-enhanced. This chapter presents key environments and methods, and their potential impact on future classroom design. The study offers a significant map for both scholars and practitioners to overview key elements in the design of future learning spaces and methods.

11.1 Introduction

The landscape of education is constantly changing, with advancements in technology and shifts in pedagogical approaches shaping the design of learning spaces (Cheung et al., 2021). These spaces, which can be physical or virtual (Zhong et al., 2020), indoor or outdoor (van den Bogerd et al., 2020), teacher-centered or student-centered (Murphy et al., 2021), play a crucial role in fostering effective learning experiences for students (Matthews et al., 2011). Oblinger (2006) describes learning spaces as environments where learning takes place, emphasizing that it is the central activity of educational institutes. These spaces encompass both formal learning settings such as classrooms, as well as informal learning situations that arise from interactions

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between individuals. Whether physical or virtual, the nature of the space can significantly influence the learning experience (Suraini & Aziz, 2023). This has the capacity to foster social connections, inspire exploration, facilitate collaboration, and stimulate meaningful discussions (Fraser, 2013; Vosniadou et al., 2012). However, the design of the space can also communicate unspoken messages, such as silence and disconnection (Oblinger, 2006). Moreover, there are several issues that have been raised over the years (Sara et al., 2021).

The traditional classroom design with rows of desks facing a teacher at the front of the room does not adequately support modern teaching and learning environments nor learning methods (Cheung et al., 2021). The shift toward more collaborative, interactive, and technology-driven learning has led to the need for new dynamic classroom designs that can facilitate these learning methods (Holmes et al., 2015). Despite the evolution of several designs, there is a lack of consensus on the different designs of future classrooms that can support diverse learning needs and styles (Shnai, 2017). For instance, what are the different learning spaces supported by technologies.

There is also a need to understand how different learning methods can be supported by different classroom designs (Rands & Gansemer-Topf, 2017). For example, project-based learning may require more open and flexible spaces (Eickholt et al., 2019), while lecture-based learning may require a more structured layout (Orji & Ogbuanya, 2018). Additionally, there is a need to consider the impact of classroom design on student well-being, such as lighting, acoustics, and air quality (Sadick & Issa, 2017).

The problem is that there is a lack of clarity on how to design future classrooms that can accommodate different learning methods and needs while also promoting student well-being (Oberle, 2018). Researchers recommended that rapid reviews could provide clarifications as they provide knowledge synthesis to produce information in a timely manner (Tricco et al., 2015). Therefore, this chapter aims to address this problem by conducting a rapid review of learning space designs and learning methods to provide insights into the design of future classrooms. The significance of the review is in providing an overview of various learning space designs and learning methods that may shape the future of classroom design.

11.2 Literature Review

Previous reviews have shown that there are several variables related to the learning environment design, such as physical (Barrett et al., 2017), social (Maxwell, 2016), cultural (Vosniadou et al., 2012), among many (Fraser, 2013; McCarley et al., 2016).

11.2.1 Learning Space Designs

Suraini and Aziz (2023) conducted a review on the current trends in physical learning environments. They emphasized the presence of ambiguity surrounding the term “learning spaces” and its interchangeability with other related terms, particularly “learning environments,” as observed in various studies. In a separate study, Martínez-Ramos et al. (2021) examined the utilization and design process of Learning Spaces as a means of supporting Sustainable Development (SD). They highlighted the limited existing research on how different Learning Spaces (LS) can’t contribute to achieving Sustainable Development goals. Furthermore, Sara et al. (2021) attempted to develop criteria for evaluating the functional performance efficiency of Learning Spaces. However, they encountered challenges due to the rapid development of modern pedagogical methods, including teaching and learning approaches, as well as the spatial environments in which they are implemented.

Zainuddin et al. (2020) conducted a study that focused on the development processes of learning spaces in higher education. Their research specifically examined space-related issues in higher education, including learning space planning, campus planning, and construction design. In a separate study, Eradze et al. (2019) conducted a systematic review aiming to understand the potential synergies between learning design (LD) and classroom observation (CO). Their findings suggested that the utilization of ICT tools to support the design process could enhance the extraction of contextual information from observations and facilitate the analysis within a pedagogical framework. However, they identified a potential limitation in the reviewed papers, noting a lack of explicit descriptions or omissions regarding the LD and CO processes or artifacts, which may have resulted in deviations in the codifications.

Several other prior studies have reviewed the development of learning spaces (Minocha & Reeves, 2010; Turner et al., 2013; Talbert & Mor-Avi, 2019), and they all acknowledged limitations. Turner et al. (2013) conducted a review on learning spaces within academic libraries and identified challenges in establishing a definitive and widely accepted working definition. Additionally, Minocha and Reeves (2010) offered concise design guidance and examples to assist educators and designers in creating learning spaces that promote socialization, informal learning, collaboration, and creativity among students. However, there is a lack of guidance or research concerning how 3D learning spaces should be designed to effectively support student learning and engagement. Furthermore, Talbert & Mor-Avi (2019) highlighted that there is a need for grounded research on Active Learning Classrooms (ALCs) and they review the literature on design elements of ALCs and their effects on learning outcomes, student engagement, and instructor behaviors. Nevertheless, these previous analyses failed to provide a substantial, comprehensive, and rigorous framework for assessing the overall impact across various criteria related to design objectives, practical implementation, and the learning experiences of both staff and students.

11.2.2 Learning Methods

Research on learning space designs is fundamental to the development of learning methods, since the physical environment plays a crucial role in shaping educational experiences (Brooks, 2011; Maxwell, 2016). By examining how different learning spaces are designed and utilized, educators can develop effective strategies and approaches that enhance student engagement, collaboration, and overall learning outcomes (Barrett et al., 2017). For instance, McCombs (2017) conducted a historical review of learning strategies considering wholistic approaches on learner, and recommended that future research should consider the increasing complex, digital, and diverse world. Several other studies offered valuable insights into different learning methods and their effectiveness for life-long learning, interactive learning, and improving student learning outcomes (Dunlosky et al., 2013; Lile & Kelemen, 2014; Liubchenko, 2016).

A monograph on improving students' learning with effective learning techniques addressed the need to enhance educational outcomes by helping students regulate their learning using proven techniques (Dunlosky et al., 2013). Ten learning techniques were discussed, including elaborative interrogation, self-explanation, summarization, highlighting, keyword mnemonic, imagery use, rereading, practice testing, distributed practice, and interleaved practice. The techniques were evaluated based on their utility across learning conditions, student characteristics, materials, and criterion tasks.

Another research on strategies of teaching/learning/assessment based on interactive learning methods explored various active learning methods aimed at promoting critical thinking, creativity, and multiple intelligences (Lile & Kelemen, 2014). The authors reviewed the perspectives of students, teachers, and educational researchers, emphasizing the importance of motivation and deep understanding in learning. The adoption of modern methods was found to stimulate knowledge relationships, inference, cognitive independence, and student self-confidence (Ibid).

Furthermore, Liubchenko (2016) reviewed teaching methods for life-long learning, and examined six popular methods: case method, enquiry-based learning, spiral learning, problem-based learning, project-organized learning, and b-learning. The paper evaluated the usefulness of each method for life-long learning (LLL) courses and identified their relevance. He provided recommendations for selecting appropriate teaching methods for LLL. It also highlights that there is a growing body of research on the impact of technology on classroom design and learning outcomes.

Additionally, Van Alten et al. (2019) conducted a meta-analysis on the effects of flipped classrooms in secondary and postsecondary education. Flipped classrooms are a pedagogical approach where students study instructional material before class and apply it during class. The findings revealed a small positive effect on learning outcomes, but no effect on student satisfaction regarding the learning environment. The authors also found considerable heterogeneity between the 114 included studies. Students in flipped classrooms achieved higher learning outcomes when face-to-face class time was not reduced compared to non-flipped classrooms or when quizzes were added in the flipped classrooms (Van Alten et al., 2019). Based on the findings, the authors conclude that a flipped classroom approach is a promising pedagogical approach when appropriately designed. Their results provide insights into effective instructional design characteristics that support an evidence-informed application of the classroom design (Ibid).

Overall, prior related work suggests that classroom design and learning methods can have a significant impact on student learning outcomes and well-being (Sadick & Issa, 2017; van den Bogerd et al., 2020). The shift toward more collaborative and interactive learning (Miyake & Kirschner, 2014; Mokhtarmanesh & Ghomeishi, 2019), as well as the integration of technology (Holmes et al., 2015; Van Alten et al., 2019), has led to the development of new classroom designs that can support these learning methods (Triyason et al., 2020). However, there is a need to map these learning environments and approaches in support of the design of future classrooms that can accommodate diverse learning needs while also promoting student well-being.

11.3 Methodology

In this paper, a rapid literature review was conducted to examine the relationship between learning space designs and learning methods, with a specific focus on their impact on designing future classrooms. The review followed a rapid review procedure as outlined by Dobbins (2017), ensuring a rigorous and efficient approach.

11.3.1 Search Strategy

A thorough search was conducted using the Google Scholar electronic database, targeting peer-reviewed articles published in academic journals between 2002 and 2022. The selection of the search terms was carefully considered to encompass relevant aspects of the topic. The used search terms included "learning space design," "learning methods," "active learning," "collaborative learning," "flipped classroom," and "technology-enhanced learning." The search was limited to articles published in English to maintain consistency and accessibility.

To provide readers with a clearer understanding of the search process, it is worth noting that a diverse range of academic journals was included in the search, covering various disciplines related to educational education, pedagogy, and learning sciences. The initial number of manuscripts retrieved from the early search was 31 articles. This was enriched through snowball sampling (Parker et al., 2019) by adding references from these 31 articles. Snowball sampling technique can be useful in rapid reviews by facilitating the identification and inclusion of relevant studies within a short timeframe (Stevens et al., 2018). In rapid reviews, the goal is to quickly gather evidence and synthesize findings to inform decision-making or policy development.

11.3.2 Selection Criteria

To ensure the relevance and quality of the articles included in the review, specific selection criteria were applied. Each article had to meet the following criteria to be included:

(1) The article focused on learning space designs or learning methods.
(2) The article was published between 2002 and 2022 to capture the most recent research in the field.
(3) The article was written in English for consistency and accessibility.

Through snowball sampling selection criteria (Parker et al., 2019), several other manuscripts were selected based on their relevance. For instance, Lorenzo and Gallon (2019) was identified in the initial search (see Sect. 4.1), which cited Ochola and Achrazoglou (2015). This citation (Ibid) was selected to be included in this rapid review, due to its relevance to smart learning spaces through the focus on interactions and collaboration.

11.3.3 Data Extraction and Analysis

Following the initial search, a careful screening process was employed to evaluate the relevance of articles based on their titles and abstracts. The screening aimed to identify articles that aligned with the selection criteria and would contribute significantly to the review. The final selection of articles was then subjected to a thematic analysis, enabling the identification of common themes and patterns across the studies, which would help formulate key concepts for the design of future classrooms.

Furthermore, the data collection process involved a careful examination of the methodology, results, and discussions presented in each article, allowing for a comprehensive understanding of the research findings. By adhering to this rigorous methodology, the review synthesized the relevant findings from the selected articles and drew conclusions regarding the effectiveness of different learning space designs and learning methods in enhancing student learning outcomes.

11.4 Findings

The findings are organized in two main sections, learning environments and learning methods.

11.4.1 Learning Environments

From an ontological perspective, a "learning environment" can be understood as a complex entity that consists of various components that interact with each other to facilitate learning (Herrington et al., 2014). At its most basic level, a learning environment is a physical or digital space in which learning takes place (Meyers et al., 2013). This space can include classrooms, laboratories, libraries, online learning platforms, and other educational settings. However, a learning environment is much more than just a physical or digital space (Mohamed et al., 2020). It also encompasses the cultural, social, and cognitive dimensions of learning (Fraser, 2013; Vosniadou et al., 2012). This includes the beliefs, values, and practices of the learners and educators involved, as well as the relationships between them (McCarley et al., 2016).

Moreover, a learning environment is not a static entity but is constantly evolving. It is influenced by various factors such as the learners' prior knowledge and experiences (Land et al., 2012), the curriculum (Andersone, 2017), the instructional methods used (Treagust, 2013), and the resources available (Askhamov et al., 2016). Therefore, a learning environment can be seen as a dynamic system that is shaped by multiple factors and influences, and that has the potential to facilitate or hinder learning depending on how these factors interact. In this section, several spaces were identified in the literature (see Fig. 11.1).

11.4.1.1 Physical Learning Environments

The terms "learning space" and "learning environment" are closely related but they refer to slightly different concepts (Campbell, 2020). A learning space typically refers to the physical or virtual location where learning takes place (Painter et al., 2013).

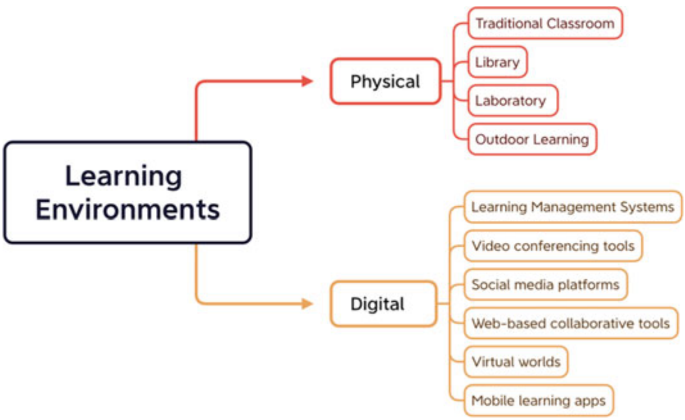

Fig. 11.1 Various learning environments

This can include a classroom, a library, a laboratory, an online platform, or any other location where learners are engaged in learning activities. The focus of a learning space is primarily on the physical or virtual features that facilitate learning, such as seating arrangements, lighting, acoustics, technology, and other design elements.

On the other hand, a learning environment is a broader concept that encompasses more than just the physical or virtual space (Kolcu & Kolcu, 2021). A learning environment includes the social, cultural, and cognitive factors that contribute to learning, such as the learners' prior knowledge and experiences (Land et al., 2012), the instructional methods used, the resources available, the relationships between learners and educators, and the overall culture of the learning community. In other words, a learning environment is a more holistic concept that takes into account the entire ecosystem of learning (Brown et al., 2015), while a learning space is more focused on the physical or virtual features that support learning (Painter et al., 2013).

- **Traditional Classroom**: This is the most common type of a physical space where students attend classes with a teacher and interact with classmates. The classroom is equipped with desks, chairs, a whiteboard or blackboard, and other teaching aids (Clinton & Wilson, 2019).
- **Library**: This is a space where students can access books, journals, and other resources to support their learning of reading and literacy (Eyre, 2012).
- **Laboratory**: This is a space designed for conducting experiments and hands-on learning activities, often used in science, engineering, and medical education (Towns et al., 2015). Lab-based learning environments offer students the opportunity to engage in hands-on experiments and activities to deepen their understanding of a particular subject, such as in science, technology, engineering, and mathematics (STEM) fields (West et al., 2021).
- **Outdoor Learning**: Outdoor learning involves taking students outside of the previously mentioned settings to learn in a natural or outdoor setting, such as a park or forest, through activities such as field trips, nature walks, and outdoor education programs (Dillon et al., 2016). These environments provide opportunities for students to connect with nature and engage in experiential learning activities to deepen their understanding of various subjects (Ibid). Other examples include museums or art galleries (Longstaffe, 2020), historical sites (Saputro, 2021), community centers (Donohue, 2012), botanical gardens (Glackin & Harrison, 2018), national parks (McGown et al., 2012), or zoos and aquariums (Ballantyne & Packer, 2016).

11.4.1.2 Digital Learning Environments

Digital learning spaces have become increasingly popular in recent decades as educational institutions and organizations seek to offer flexible and accessible learning opportunities to learners around the world (Faour et al., 2012). While the terms e-Learning, online learning, and distance learning are often used interchangeably, a study by Moore et al. (2011) explores the differences between these types of learning environments. The study argues that while e-Learning, online learning, and distance learning environments share some similarities in terms of their use of technology, they also have distinct characteristics that set them apart. Understanding these differences is essential for educators and learners alike as they navigate the rapidly evolving landscape of virtual learning spaces. The following are important terminologies found in the literature:

- **Learning Management Systems (LMS)**: These are online platforms that allow educators to deliver course materials, assignments, and assessments to students (Mahnegar et al., 2012). Examples of LMSs include Blackboard (Moonsamy & Govender, 2018), Canvas, and Moodle (Mpungose & Khoza, 2022).
- **Video Conferencing Tools**: These tools allow live, synchronous communication between educators and students in real-time (Camilleri & Camilleri, 2022). Examples include Zoom, Microsoft Teams, Tencent Meeting, and Google Meet among others (Singh & Awasthi, 2020).
- **Social Media Platforms**: Social media platforms such as Facebook, Twitter, and Instagram can be used to facilitate communication and collaboration between educators and students (Van Dijck & Poell, 2018).
- **Web-Based Collaborative Tools**: These tools enable students to work together on projects and assignments in real-time, regardless of their physical location (Le, 2022). Examples include Google Docs, Dropbox, and Trello (Schrameyer et al., 2016).
- **Virtual Worlds**: These are immersive 3D environments that simulate real-world scenarios and provide opportunities for experiential learning (Dawley & Dede, 2014). Examples include Second Life and Minecraft (Rospigliosi, 2022).
- **Mobile Learning Apps**: These are apps designed for mobile devices that allow students to access course materials, complete assignments, and communicate with educators and classmates on-the-go (Elfeky & Masadeh, 2016). Examples include Duolingo, Quizlet, and Khan Academy (Rataj & Wójcik, 2020).

11.4.2 Learning Methods

Learning methods refer to the various approaches used to facilitate learning in educational settings (Entwistle & Ramsden, 2015). There are five main approaches to learning methods, which include teacher-led approaches, student-centered approaches, active learning approaches, collaborative approaches, and technology-enhanced approaches (see Fig. 11.2). Each approach has its unique characteristics and techniques, but some overlap. For instance, teacher-led approaches include direct instruction, lecture-based instruction, demonstration-based instruction, drill and practice, and scaffolded instruction. Student-centered approaches include inquiry-based learning, project-based learning, problem-based learning, self-directed learning, and differentiated instruction. Active learning approaches include flipped learning, blended learning, experiential learning, role-playing, and simulations, while collaborative approaches include collaborative learning, peer teaching, peer assessment, group projects, and think-pair-share. Lastly, technology-enhanced

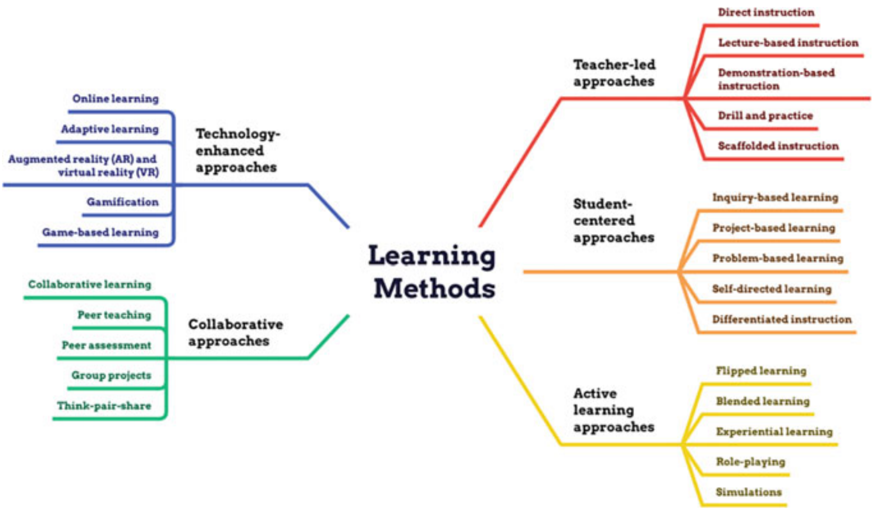

Fig. 11.2 Five approaches to learning methods

approaches include online learning, adaptive learning, augmented reality (AR) and virtual reality (VR), gamification, and game-based learning.

11.4.2.1 Teacher-Led Approaches

These approaches emphasize the role of the teacher in guiding and directing the learning process (Lorenzo & Gallon, 2019; Wei & Cheng, 2022).

- **Direct Instruction**: This approach involves a teacher-led approach to learning where information is presented in a structured and sequenced manner (Wallace et al., 2020). It emphasizes explicit teaching, repetition, and mastery of content.
- **Lecture-Based Instruction**: This approach involves a teacher delivering information to students through a lecture or presentation format (Carriger, 2016). It emphasizes the teacher's expertise and knowledge as the primary source of information.
- **Demonstration-Based Instruction**: This approach involves a teacher demonstrating a skill or process to students, and then having students practice the skill or process themselves (Ryan, 2022). It emphasizes modeling and imitation.
- **Drill and Practice**: This approach involves repetitive practice of skills and concepts to promote mastery (Lehtinen et al., 2017). It emphasizes memorization and repetition.
- **Scaffolded Instruction**: This approach involves gradually releasing responsibility for learning from the teacher to the student, through the use of different levels of support (D'Costa & Schlueter, 2013). It emphasizes the importance of providing support and guidance to help students build on their prior knowledge and skills.

11.4.2.2 Student-Centered Approaches

These approaches emphasize the learner and their needs, interests, and abilities (Kaput, 2018). Examples include inquiry-based learning, project-based learning, problem-based learning, self-directed learning, cooperative learning, and differentiated instruction.

- **Inquiry-Based Learning**: This approach emphasizes student-led exploration and investigation of a topic or problem (Pedaste et al., 2015). It involves asking questions, seeking information, and making connections to develop a deeper understanding of concepts.
- **Project-Based Learning**: This approach involves students working on a specific project or task that requires them to apply their knowledge and skills to solve a real-world problem (Eickholt et al., 2019). It emphasizes collaboration, critical thinking, and creativity.
- **Problem-Based Learning**
- : This approach involves presenting students with a real-world problem or scenario and guiding them through a process of inquiry and analysis to develop solutions (Yew & Goh, 2016). It emphasizes critical thinking, collaboration, and problem-solving skills.
- **Self-Directed Learning**: This approach involves students taking responsibility for their own learning, setting their own goals, and managing their own learning process (Boyer et al., 2014). It emphasizes autonomy, self-motivation, and self-reflection.
- **Differentiated Instruction**: This approach involves tailoring instruction to meet the diverse needs of individual learners (Smale-Jacobse et al., 2019). It emphasizes flexibility, student-centeredness, and personalized learning.

11.4.2.3 Active Learning Approaches

These approaches emphasize hands-on, experiential learning and engagement with the material (Brame, 2016). Examples include flipped learning, blended learning, experiential learning, role-playing, and simulations.

- **Flipped Learning**: This approach involves reversing the traditional classroom model by having students engage with content outside of class (e.g., through videos or readings) and using class time for activities that allow for deeper learning and application of content (Karabulut-Ilgu et al., 2018). It emphasizes active learning, engagement, and application of knowledge.
- **Blended Learning**: This approach combines traditional face-to-face instruction with online learning activities, such as virtual discussions, videos, and interactive simulations (Dangwal, 2017). It offers students flexibility and personalized learning options.

- **Experiential Learning**: This approach involves learning through direct experience and reflection (Kolb, 2014). It emphasizes active participation, hands-on learning, and real-world application of knowledge and skills.
- **Role-Playing**: This approach involves students taking on different roles or perspectives to explore a topic or scenario (Hammer et al., 2018). It emphasizes empathy, communication, and critical thinking.
- **Simulations**: This approach involves creating realistic scenarios or models to simulate real-world experiences (Jeffries et al., 2016). It emphasizes problem-solving, decision-making, and critical thinking.

11.4.2.4 Collaborative Approaches

These approaches emphasize learning through collaboration and teamwork (Laal & Ghodsi, 2012). Examples include cooperative learning, collaborative learning, and the Reggio Emilia approach (Wien, 2015).

- **Collaborative Learning**: This approach involves students working together in groups to achieve a common learning goal (O'Donnell & Hmelo-Silver, 2013). It emphasizes communication, teamwork, and peer-to-peer learning (Ochola & Achrazoglou, 2015).
- **Peer Teaching**: This approach involves students teaching and instructing their peers (Stigmar, 2016). It emphasizes collaboration, communication, and leadership skills.
- **Peer Assessment**: This approach involves students assessing and providing feedback on each other's work (Double et al., 2020). It emphasizes critical thinking, communication, and metacognition.
- **Group Projects**: This approach involves students working on a project together to achieve a common goal (Ekblaw, 2017). It emphasizes collaboration, communication, and problem-solving skills.
- **Think-Pair-Share**: This approach involves students working in pairs or small groups to discuss a topic or question, and then sharing their ideas with the larger group (Sampsel, 2013). It emphasizes communication, collaboration, and active participation.

11.4.2.5 Technology-Enhanced Approaches

These approaches emphasize the use of technology to support and enhance learning (Kirkwood & Price, 2014). Examples include online learning, adaptive learning, augmented reality (AR) and virtual reality (VR), gamification, and game-based learning.

- **Online Learning**: This approach involves delivering instruction and content through the internet, using a learning management system (LMS) or other online platforms (Singh & Thurman, 2019). It emphasizes flexibility, accessibility, and personalized learning.

- **Adaptive Learning**: This approach involves using technology to personalize learning for individual learners, based on their needs, interests, and abilities (Kerr, 2016). It emphasizes personalized learning, feedback, and mastery.
- **Augmented Reality (AR) and Virtual Reality (VR)**: These approaches involve using technology to create immersive, interactive learning experiences (Elmqaddem, 2019). AR adds digital content to the real world, while VR creates a fully simulated environment (Moro et al., 2021). They emphasize experiential learning, engagement, and visualization.
- **Gamification**: This approach involves using game-like elements to non-game activities, such as points, badges, and leaderboards, to motivate and engage learners (Caponetto et al., 2014). It emphasizes competition, collaboration, and problem-solving.
- **Game-Based Learning**: Game-based learning is an instructional approach that uses video and computer games to provide instruction (Tobias et al., 2014). Its effectiveness is demonstrated in areas such as transfer of skills from games to external tasks, enhancement of cognitive processes, and integration with curricular objectives.

11.5 Discussion and Conclusion

This study provides a rapid review to the literature on learning environments and learning methods. The findings reveal several environments (physical and digital), and methods (teacher-led, student-centered, active learning, collaborative, and technology-enhanced approaches). These findings complement previous reviews (Eradze et al., 2019; Zainuddin et al., 2020; Martínez-Ramos et al., 2021; Sara et al., 2021; Suraini & Aziz, 2023) by mapping the learning environments and approaches in support of the design of future classrooms.

The implications of this rapid review involve theoretical and practical areas. Besides the specific environments and approaches identified in Sect. 11.5, the findings reveal several themes that are crucial to the design of future classrooms in theory and practice. Figure 11.3 shows ten key areas that are involved. The design of future classrooms is critical to creating a learning environment that is conducive to student success and achievement. The various components of the learning environment, including physical space, pedagogy, assessment, technology integration, teacher professional development, student well-being, career readiness, sustainability, community connections, and policy and governance, all play a crucial role in shaping the learning experience.

Classroom design and physical environment. The findings recognize the impact of classroom design and physical environment on students' learning outcomes and student experiences, which is in line with the literature (Van Alten et al., 2019). Future classrooms should prioritize flexible layouts, ergonomic furniture, adaptable spaces, and aesthetics that promote motivation, creativity, and well-being (Barrett et al.,

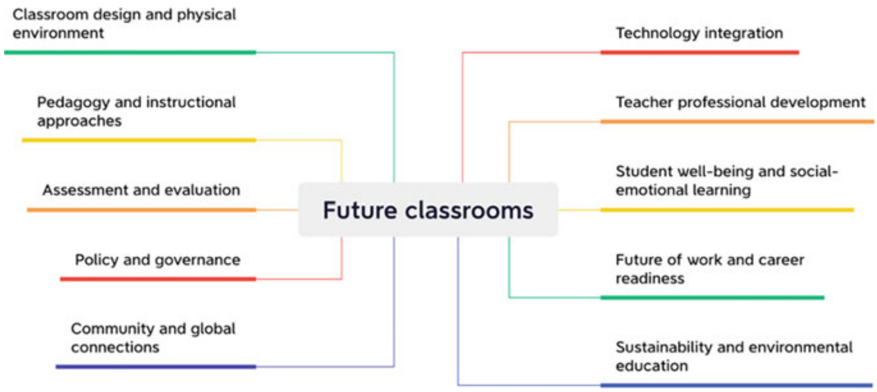

Fig. 11.3 Key areas involved with the design of future classrooms

2017). The design should also facilitate movement, accessibility, and the integration of technology to support diverse learning activities and preferences (Martínez-Ramos et al., 2021).

Technology integration. The findings also highlight the significance of integrating technology into future classrooms to support innovative pedagogical approaches and enhance learning outcomes (Van Alten et al., 2019). It emphasizes the importance of leveraging digital resources, interactive displays, and collaboration tools to engage students and develop their digital literacy skills (Laal & Ghodsi, 2012). Future classrooms should be equipped with appropriate technological infrastructure to facilitate personalized learning and student engagement. This may include interactive displays, access to digital resources, and collaboration tools that support active participation and knowledge construction (Wien, 2015).

Pedagogy and instructional approaches. Several studies emphasize the importance of evolving pedagogy and instructional approaches in future classrooms (Hod, 2017). The findings recognize the need to move away from traditional teacher-centered instruction toward learner-centered approaches (Murphy et al., 2021). Educators should embrace learner-centered approaches, active learning strategies, and personalized instruction. Future classrooms should also provide flexible learning spaces, promote collaboration and critical thinking, and leverage technology to enhance engagement and knowledge construction (Shehata et al., 2023).

Teacher professional development. This review emphasizes the importance of providing teachers with continuous professional development opportunities to effectively utilize future classroom designs and learning methods (Bredeson, 2002). It recognizes that teachers need to adapt their instructional practices to leverage technology and create inclusive learning environments. Educational institutions should invest in comprehensive training programs that equip teachers with the necessary skills to integrate technology, implement student-centered approaches, and create inclusive and supportive learning environments (Shehata et al., 2023). This includes training on digital tools, pedagogical techniques, and strategies for addressing diverse student needs (Jaffer et al., 2007).

Assessment and evaluation. The findings acknowledge the need for future classrooms to adopt innovative assessment and evaluation methods that align with new pedagogical approaches (Ryan & Tilbury, 2013). It recognizes the limitations of traditional assessment methods in capturing holistic learning outcomes (Pereira et al., 2016). Educators should explore alternative assessment methods, such as project portfolios, performance-based assessments, and self-reflection, to measure students' progress and provide meaningful feedback. Future classrooms should also incorporate technology-enabled assessment tools and data analytics to track individual and collective learning outcomes (Valaskova et al., 2022).

Student well-being and social-emotional learning. The study highlights the role of future classrooms in promoting student well-being and supporting social-emotional learning (Oberle, 2018). It acknowledges the importance of creating environments that foster emotional intelligence, resilience, and positive relationships among students (Trigueros et al., 2019). Future classroom designs should prioritize factors such as natural lighting, ergonomic furniture, and dedicated spaces for relaxation and reflection. Educators should incorporate social-emotional learning strategies into their instructional practices to promote student well-being, self-awareness, and positive social interactions (Holmes et al., 2015).

Policy and governance. The study emphasizes the role of policy and governance in shaping the design and implementation of future classrooms (Daly-Smith et al., 2020). It recognizes the need for policymakers to prioritize resource allocation and establish guidelines for equitable access to educational resources. Policymakers should prioritize the allocation of resources for infrastructure development, technology integration, and professional development. They should also establish guidelines and standards for classroom design, pedagogical practices, and equitable access to educational resources (Kazem & Al-Kazzaz, 2022).

Future of work and career readiness. The study acknowledges the importance of preparing students for the future of work by equipping them with relevant skills and competencies (Torii & O'Connell, 2017). It recognizes the need for students to develop problem-solving, collaboration, and adaptability skills. Future classroom designs should incorporate spaces that promote collaborative work, problem-solving, and skill development. Educators should integrate real-world applications, project-based learning, and industry partnerships to enhance students' career readiness and ability to navigate a rapidly changing job market (Lee et al., 2022).

Community and global connections. The study highlights the importance of future classrooms in facilitating community and global connections to broaden students' perspectives and promote cultural competency (Donohue, 2012). It emphasizes the value of virtual collaborations and cultural exchanges. Future classroom designs should incorporate spaces and technologies that enable virtual collaborations, cultural exchanges, and community involvement (Vosniadou et al., 2012). Educators should integrate global perspectives, facilitate online connections with experts and peers from diverse backgrounds, and encourage students to actively engage with local communities (Fraser, 2013).

Sustainability and environmental education. The study recognizes the role of future classrooms in promoting sustainability and environmental education to foster ecological consciousness (Kronlid & Öhman, 2013). It highlights the importance of nurturing students' understanding of environmental issues and encouraging sustainable practices. Future classroom designs should incorporate eco-friendly materials, energy-efficient technologies, and opportunities for hands-on environmental learning. Educators should integrate sustainability themes across the curriculum, engage students in conservation efforts, and promote environmental stewardship (Cole, 2014).

In conclusion, the rapid review of learning space designs and learning methods has shed light on the importance of creating effective learning environments that promote student engagement and success. The findings demonstrate that successful learning environments should be adaptable to the needs of different learners, incorporate the latest technologies, and provide opportunities for collaboration and interaction. The findings also suggest that future classrooms should be designed to accommodate different learning styles and promote student-centered approaches to teaching and learning.

Despite that this study followed a rigorous rapid review methodology, it still has several limitations that should be acknowledged and further researched. For instance, the obtained results are limited by the used search keywords and electronic databases. Additionally, this study included only publications in English. This research could therefore be enriched by integrating other types of databases in other languages, in addition to English.

Future research may also consider in-depth research on the key areas involved with the design of future classrooms (see Fig. 11.3). Overall, this review provides a valuable resource for educators, policymakers, and designers seeking to create effective and engaging learning environments for students.

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Chapter 12
A Systematic Review and Research Trends of Smart Learning Environments

Lan Zhang, Rouye Pan, Zihan Qin, and Junfeng Yang

Abstract Smart Learning Environments (SLEs) have evolved rapidly over the past 20 years. However, current investigations of SLEs have narrowly focused on specific technologies or have remained at the theoretical level without discussing the practical implications; the role and application of technology in teaching and learning aren't sufficiently clear. The purpose of this review is to systematically examine the design and learning approaches of SLEs. This study employs a literature review method, specifically analyzing the literature on SLEs in the Web of Science database. (a) SLEs are globally recognized research fields, with contemporary studies emphasizing five key areas: technical support for SLEs, the design of learning spaces, teaching and learning ways in SLEs, SLEs models and assessment of SLEs' quality. (b) Research mainly focuses on software devices like smart learning systems and platforms for technical support, with limited attention given to hardware devices. (c) The design of learning spaces is trending toward integrating virtual and physical elements. (d) Learning approaches in technology-supported SLEs focus on cooperative learning and autonomous learning. Finally, in view of the shortcomings of the current research, suggestions for future research are put forward.

12.1 Introduction

With the rapid development of global informatization, more and more countries attach importance to the deep integration of information technology and education to promote the cultivation of informatization talents. In 2008, the British Joint Information Systems Committee issued the "21st Century Learning Space Design Guidelines" and said: "In order to meet the needs of two different teaching methods, teacher-centered and student-centered, building a technology-rich learning environment is an important research trend in learning space, and learning space must also be the focus of future research" (Shi & Zheng, 2022). In recent years, new associations, such as the International Association for Intelligent Learning Environments (IASLE),

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the International Conference on Intelligent Learning Environments (ICSLE) or the International Conference on Intelligent Learning Ecosystems and Regional Development (ICSLERD), have attempted to define, incorporate and integrate emerging technologies in educational environments to construct so-called intelligent learning environments in order to improve learning performance.

SLEs are emerging learning environments that use intelligent and mobile technologies to integrate learning objects and provide intelligent learning processes for active learning experiences. The transformation of learning environment brings about great changes in students' learning styles, information extraction and information processing. It innovates the methods of intelligent learning, builds an interactive bridge between local and remote students and teachers and promotes cooperation between near and far end students. The emergence of SLEs as a rapidly growing field represents how learning objects, learning processes and learning activities are interconnected to provide personalized and inclusive learning experiences (Kubsch et al., 2022). Using intelligence and mobility, SLEs can be developed to bring personalized learning to learners' learning styles and needs. It transforms traditional learning methods into new ones, and provides a student-centered learning environment that integrates multiple teaching methods and strategies, practices and reflects on the learning process; and accept formal and informal learning situations (Singh & Miah, 2020).

Presently, the adoption of SLEs in education has been widely valued. To address sustainable development's challenges, the Decade of Education for Sustainable Development, which was declared by the United Nations in 2005, catalyzed the integration of the Education for Sustainable Development (ESD) principles into all levels of education. Education for Sustainable Development (ESD) aims to reconsider physical and virtual learning spaces based on sustainable development, which means a shift toward learner engagement, formative assessment and positive approaches in SLEs (Cebrián et al., 2020). The outbreak of the COVID-19 coronavirus pandemic at the end of 2019 has promoted the spread of education technology innovation, which has led to changes in the type of education. Schools have switched from traditional face-to-face teaching between teachers and students to synchronous and asynchronous distance learning (Gong et al., 2023), or to blended learning that combines face-to-face and online instruction. In order to put the ESD process into practice through SLEs, it is necessary to further analyze the research content and trends of technical support, space design, and learning styles of SLEs in the last decade.

12.2 Background

Under the background of the continuous development of artificial intelligence and mobile technology, SLEs emerge at the historic moment. The study of SLEs originated in Western countries, especially in Europe and the United States. Early research was conducted mainly in the United States, the United Kingdom, Canada and other countries. Over time, the research on smart learning environments has gradually expanded to other countries and regions.

Zimmerman (2015) believed that SLEs occur with the interaction between learning environment and learners. Learners can learn by observing and interacting with parents, teachers, peers and people who exhibit these behaviors. Kinshuk (2016) defined the SLE as an ecosystem that enables technology and pedagogy to merge, providing real-time and ongoing evidence of changes in knowledge and skills that learners can seamlessly absorb as they move from one learning environment to another. Many educational researchers equate learning environments with learning spaces. Learning space refers to a place and the surroundings associated with that place where teaching and learning occur; it may refer to an indoor or outdoor location, or to a physical or virtual environment (Huang, 2019).

Chinese scholars have studied the connotations and characteristics of SLEs. Zhong (2006) first proposed the concept and characteristics of SLEs, Yang and other experts and scholars (2014) also carried out relevant studies. Huang (2019) defined the intelligent learning environment as a new kind of learner-centered learning environment, through the use of smart mobile technology to detect learning scenarios, identify learners' characteristics, provide the appropriate learning resources and useful interactive tools and personalized learning guidance support, automatically record the learning process and learning result and promote effective learning places or activity Spaces for learners.

Although there is no international consensus on the definition of SLEs, scholars in the field of education generally agree that SLEs are activity spaces or places which involve the emerging notion of smart technology that can stimulate students' interest in learning, guide students to learn in activities and help students to construct their learning (Jo et al., 2016; Huang 2019; Singh, 2022).

There are many research achievements in the construction and design of SLEs, such as Kim and Scott. A typical SLE is the "Active Learning classroom" designed by the University of Minnesota Classrooms (Cotner et al., 2013), and iRoom, an interactive learning space developed by Johanson et al. (2002) at Stanford University.

In the study on the acceptance and satisfaction of SLEs, the results show that users have a positive attitude toward SLEs, and that teachers and students will choose more technical support in learning, and the experience effect is also relatively satisfied (Zhang & He, 2022). The research of Strayer proves that the role of smart school environment in collaborative learning is recognized by students, and they are willing to accept innovative teaching methods (Strayer, 2012). Zhang and He (2022) and Di et al. (2019) analyzed the influencing factors of learner satisfaction in SLEs, finding that course support, technical support, faculty support and management support have statistically significant influences on learners' satisfaction, and learning style and internet attitudes will strongly influence learners' higher-order thinking.

In the research on the design and implementation of SLEs, the focus is gradually changing from physical learning space to virtual learning space. Hu (2022) focused on the design and development of educational dashboards in intelligent learning, covering their educational data mining and visualization techniques. Intelligent and mobile technologies can be used to develop SLEs and personalize learning to meet learners' learning styles and needs. Many scholars are committed to designing virtual learning environments such as metaverse (Wang et al., 2022; Zheng et al., 2022) and personalized learning platforms with the help of intelligent technologies (Peng et al., 2019). According to the latest research, it can be found that the design of learning space shows a trend of integration of reality and imagination (Salinas-Navarro et al., 2023; Zhang & MacWhinney, 2023).

Although there are a number of reviews in the literature that have been conducted on SLEs, previous literature surveys have explored the present and future of SLEs research from a single perspective, and have remained at the theoretical level without analyzing about the empirical results of the SLEs usage. For example, Heinemann and Uskov (2018) reviewed several literature in the field of smart education including SLEs, aiming to build a more mature smart university. Rosmansyah et al. (2022) proposed a simple model that was generated by mapping of 12 existing SLEs models, frameworks and best practices. Few researches have been conducted on the practical implications of technologies in SLEs. Wong and Li (2020) focused on the devices and features involved in smart learning practices. However, the article did not provide a systematic review of the functions and effects of devices. Besides, existing literature has not systematically analyzed the different pedagogical approaches in SLEs (Li & Wong, 2021; Tabuenca et al., 2021). For example, Gambo and Shair (2021) used a systematic review to explore the self-regulated learning process in the smart learning environment. Putro and Rosmansyah (2018) provided a systematic literature review which focused on the need for intelligent technology. However, the review is narrowly focused on group learning.

The purpose of this review is to address the gap in the literature, and systematically examine the technology support for SLEs, the design and the pedagogical approaches of SLEs on both research and practice.

12.3 Methods

This review followed Kitchenham and Charters' (2007) guideline for performing a systematic literature review and was carried out through five phases: research/question/definition, search strategy design, study selection, data extraction and data synthesis.

12.3.1 Research Question

Based on the above theoretical basis, in order to adapt to the change of learning mode and promote the improvement of information literacy and advanced cognitive acquisition of students, experts, scholars and teachers are required to deepen their understanding of SLEs, master the latest development direction and research content, which can provide valuable reference content for designing and adjusting SLEs.

Q1. What are the international trends in SLEs research between 2013 and 2023?

Q2. How can technology be used to support the construction and design of SLEs?

Q3. What are the learning methods in SLEs?

12.3.2 Search Strategy

The search was conducted in reputable computing databases, namely Web of Science, using the following keywords: "smart learning environment" or "intelligence learning environment" or "smart learning space" or "intelligence learning space".

12.3.3 Study Selection

The screening process consists of two steps: the first step is preliminary screening, and the second step is screening according to detailed criteria.

Selection Stage 1: Preliminary screening was conducted according to the title of the literature.

Selection Stage 2: This stage applied the following selection criteria to identify studies relevant to the research questions (See Table 12.1).

Table 12.1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
The paper carried out research with ILE/SLE as the background	Papers unrelated to the topic (the primary focus is not on using technology for learning/teaching)
A study of SLE/ILE components	If the same research is conducted in multiple articles, all articles except for the latest one are excluded
Part of the study is related to SLE/ILE	Proceedings of meetings, articles from research institutions and educational organizations
Articles that provide results	Unable to access the full article
Research on SLE/ILE subcontents based on SLE/ILE Theory	Articles whose main research direction is e-learning or M-learning
Articles those develop models or design tools, or establish standards to support research on SLEs	Articles without keywords and research results
Articles published in journals with the same research direction that meet the above inclusion criteria	Published articles that meet the above exclusion criteria

First of all, it is necessary to make clear that the subject of this study is SLEs, namely Smart Learning Environment and Intelligent Learning Environment. Therefore, literatures on Ubiquitous Learning, e-learning, M-learning Environment and Virtual Learning Environment should be excluded.

The search terms in the databases generated 592 articles. The first screening excluded 447 articles, and the remaining 145 articles entered the second screening. In the second stage, 69 literatures were removed again according to inclusion and exclusion criteria, and finally 76 qualified literatures were left (see Fig. 12.1).

Critical Appraisal of Evidence: In this study, a variety of methods were used to ensure the quality of the selected literature. First, the research was searched based on the Web of Science database. Second, this study selected works of literature published in core journals as sources. Thirdly, the research content, research methods and research conclusions of the literature were reviewed strictly according to the inclusion and exclusion criteria.

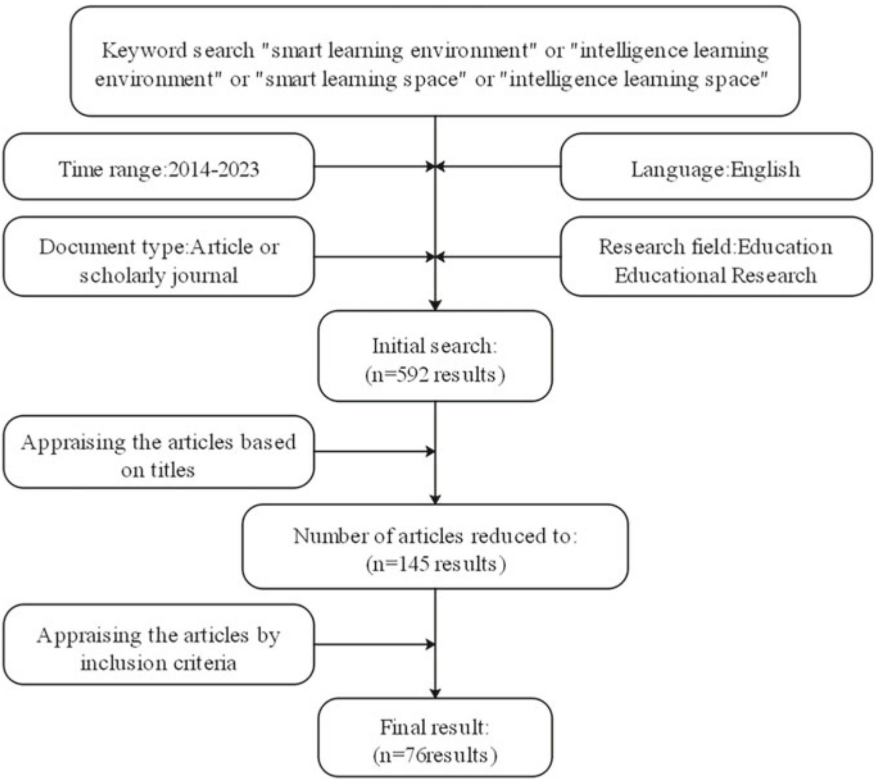

Fig. 12.1 Review process

12.3.4 Data Analysis

This study used Edelo and Kyngäs' (2010) inductive content analysis method to understand the status quo and development trend of SLEs in foreign countries between 2013 and 2023, how to use technology to support and evaluate SLEs, and the teaching and learning mode in SLEs. The steps are: selecting the unit of analysis, making sense of the data and the whole, open coding, coding sheets, grouping, categorization, abstraction and conceptual mapping.

12.3.5 Data Extraction

An Excel form was designed to aid data extraction (Table 12.2). According to the key information of the code table, the literature is further analyzed and sorted out. 43 of the 76 valid literatures involve the application of technology, which shows that technical support is the biggest feature of SLEs. Because technologies such as big data, robotics, learning analytics, Internet of Things, virtual reality, augmented reality, 3D printing and cloud services are having a big impact on education and teaching. Enhancing intelligence with data, eliminating "information islands" and connecting and integrating data are the core issues for creating intelligent learning, which need the support of technical standards and the promotion of policy mechanisms. In addition, studies on learning strategies in SLEs are also extensive. To get to the bottom, the construction of SLEs is to satisfy students' learning.

This study finds that SLEs have become a research area of global concern, and that contemporary research focuses on five aspects of SLEs: technical support, teaching and learning, models, assessment, and the construction. Most of these studies focus on technical support, teaching and learning of SLEs. Table 12.3 shows the number of papers about each aspect in Web of Science.

Table 12.2 Coding sheet

Author	Article Title	Year of Publication	Research Method	Description of Application	Hardware Technology	Software Technology

Table 12.3 Distribution of studies in each aspect

Topic content	Number of included articles
Technical support for SLEs	43
Assessment of SLEs	3
Teaching and learning in SLEs	10
The design of SLEs	34

12.3.6 Limitations of the Study

As the literature in this study is retrieved from Web of Science database, the samples are limited, so the research results only represent the research status of technology-supported SLEs included in Web of Science database, not the whole international environment research.

12.4 Results

12.4.1 Distribution of Studies

12.4.1.1 Distribution by Publication Year

From the analysis of the number of papers, the foreign literature on SLEs is on the rise. There was a lack of research on this topic from 2014 to 2023, and relevant literature has been published gradually since 2015. From 2017 to 2019, the publication of relevant literature showed a linear increase, indicating that SLEs-related research have attracted academic attention. In 2020, as most of the topics of relevant papers are based on e-learning and have low correlation with the direction determined by this study, the number of statistical papers is small. The number of posts peaked in 2022 (Fig. 12.2).

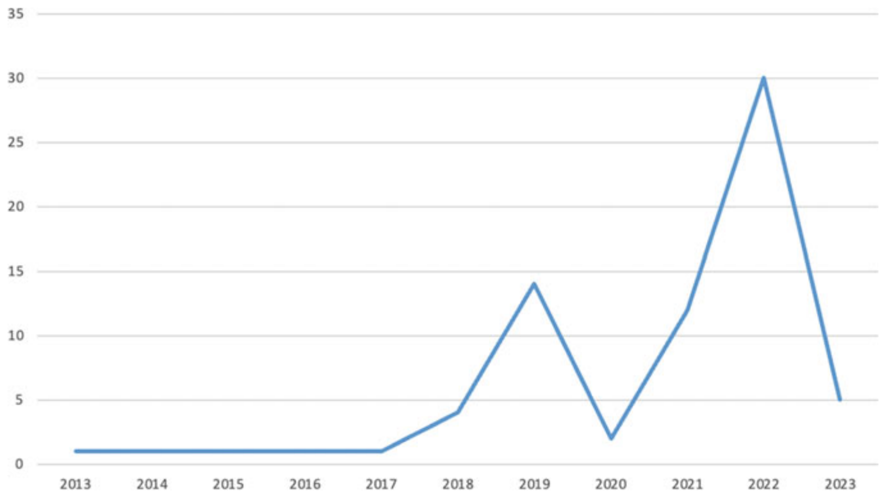

Fig. 12.2 Number of publications from 2013 to 2023

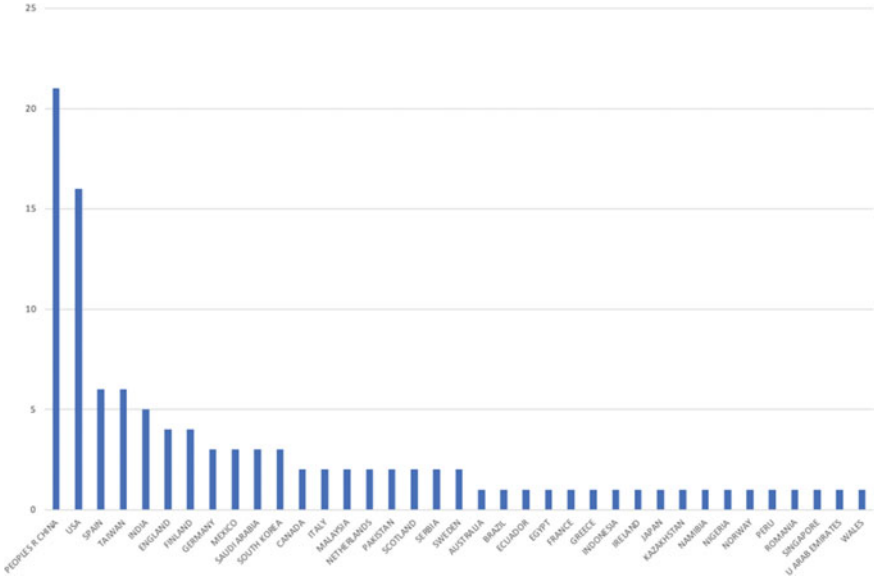

Fig. 12.3 Number of publications by country

12.4.1.2 Distribution by Countries and Regions

The geographic analysis of researchers is as follows (see Fig. 12.3). China (21) and the United States (16) emerge as the leading contributors in the field, with notable research also conducted in Spain (6), Taiwan (6), India (5), England (4), Finland (4). Additionally, several countries like Germany and Mexico have published research reports on smart learning environments, highlighting the global interest in this area of study.

12.4.1.3 Distribution by Published Journals

Published journals and statistics show that *International Journal of Emerging Technologies in Learning* and *Smart Learning Environments* has published 6 articles in total, *Interactive Learning Environments* and *Australasian Journal of Educational Technology* published 5 papers and 4 papers respectively (see Fig. 12.4). There are many other journals such as *Multimedia Tools and Applications*, *Education Science* and *Education and Information Technology* also published related articles.

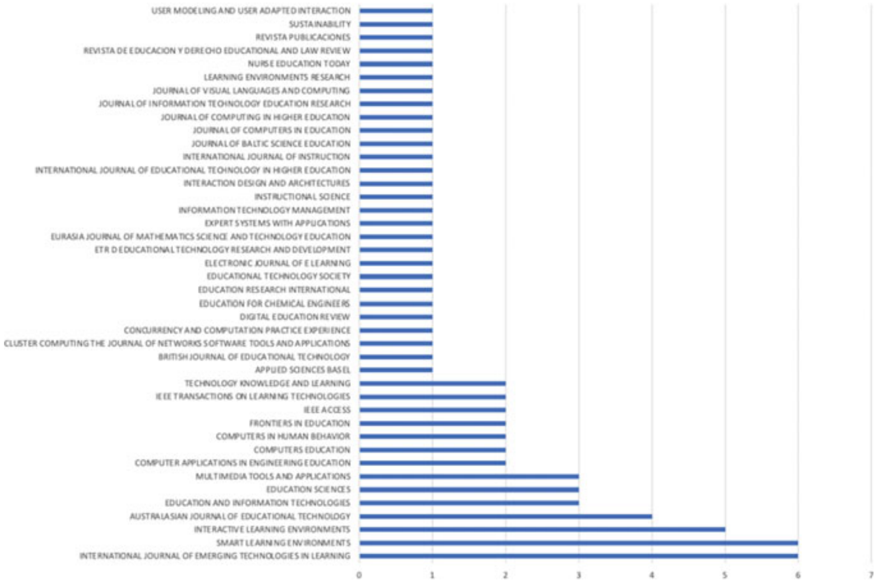

Fig. 12.4 Number of publications by journals

12.4.2 Research on Technical Support for SLEs and the Design of Technology-Supported Learning Environments

12.4.2.1 Technical Support for SLEs

In this study, 43 of the 76 works of literature screened involve the support of technology for SLEs. According to the characteristics of SLEs technology, the key technologies of SLEs are divided into hardware devices and software devices. The hardware equipment includes projectors and other infrastructure that constitute SLEs, mobile devices, other frequently used learning devices, etc. Software equipment includes tools for developing software platforms, platforms for carrying out teaching activities and subject tools for assisting teaching. Further, according to the analysis of the teaching function of the technology, the paper classifies the hardware and software equipment from the five categories of general learning support technology, interactive support technology, collaborative support tool, information presentation support technology, professional discipline tool, intelligent agent and decision technology. Table 12.4 is obtained through the statistics of the literature.

As can be seen from the analysis chart, relevant studies involve both software and hardware technologies, which are more frequently used than hardware devices, because mobile learning devices such as mobile phones, tablets and computers are essential hardware products in SLEs. From the perspective of hardware, all kinds of

Table 12.4 Frequency of use of hardware and software

Technical classification	Hardware device example	Hardware frequency	Software device example	Software frequency
Universal learning support technology	A Wi-Fi-enabled computer Smart phone The tablet AR smart glass	16	Intelligent learning system Online learning platform Digital-First Learning and Assessment Systems	9
Interactive support technology	Cameras RFID Chatbot Video conference The sensor	15	Graphical user interface Virtual reality Semantic Web technology Real-time interactive software Speech recognition software Machine learning Explainable AI	11
Collaboration support tools	Shared whiteboard A computer that supports collaborative activities Intelligent writing pad	3	Email Online multi-user, multirole playing software Smart Groups: A system	2
Information presentation support technology	A big screen The projector	7	Multimedia content rendering tool	4
Professional discipline tools			Adobe Premiere Pro CC VC tools and C language programming skills The cloud service Data collation and analysis software VR game	9

(continued)

Table 12.4 (continued)

Technical classification	Hardware device example	Hardware frequency	Software device example	Software frequency
Intelligent agent and decision technology			Data mining technology Decision tree technique Neural network technology Facial detection technology Enabling adaptive intelligent agents	9
Total		41		44

learning devices supporting wireless access and mobile communication and interactive support devices are the most frequently used in SLEs. General learning support technologies such as smart phones, tablets and computers with Wi-Fi function are the basic technologies to support the development of SLEs. Interactive support technologies such as camera equipment, video conference and sensors are the necessary technologies to optimize the interaction between teachers and students in SLEs. Mike Tissenbaum (2019) conducted a study on the infrastructure of SLEs, and found in the experiment that the hardware such as teacher's tablet computer, student's tablet computer, student's personal laptop computer, large projection display, interactive whiteboard and camera are the basic equipment for the construction of SLEs. Kapp et al. (2022) designed an augmented reality (AR) environment to compare AR glasses to a mobile device, and found that the self-efficacy results for mobile device use were higher, especially related to device handling and operating the AR environment. From the perspective of software, the development and use of intelligent learning system, online learning platform and other general learning support technology is the focus of relevant research, but there is a lack of research on collaborative support tools.

12.4.2.2 The Mainstream of Virtual Learning Spaces Design of SLEs

According to learning situation, the research divides the SLEs into two categories: physical learning space and virtual learning space.

Since the publication of the book "Learning Space", research on learning spaces has rapidly developed. In the early stage, the construction of SLEs is mainly researched on the design and transformation of physical learning space, such as technology-rich classroom initiatives (State, 2012). The "Guidelines for the Design of Learning Spaces in the 21st Century" emphasize that classroom design should prioritize the needs of both teachers and students (JISC, 2006). To accommodate various teaching modes, classrooms should be able to support personalized learning, group learning and class learning, among other learning scenarios. Additionally, the guidelines highlight the consideration of elements such as wireless networks, electronic devices, online learning environments, interactive electronic whiteboards and various learning resources in the physical design of classrooms (Yang, 2017). These factors significantly impact learners' learning experiences. Therefore, when designing learning spaces, students should be at the center, with a flexible approach that addresses their individual learning characteristics and fulfills their learning needs. Wilson & Cotgrave (2020) identified eight factors, including environment, layout, aesthetics and user preferences, that need to be considered in the design of learning spaces to ensure their suitability for a diverse student population.

Virtual learning spaces have become a hot topic with the rapid development of intelligent technology, implementation of online learning (Xie et al., 2023) and the improvement of digital competences (Pérez-Escoda et al., 2021). The focus of SLEs' construction gradually turns to how to use new technologies to build or design a virtual learning space, which integrates a variety of educational resources, including multimedia learning materials, communication tools and intelligent tutoring support (Ferro et al., 2021). Virtual learning space refers to the kind of platform that supports mediated exchange of information between users and the system through such digital media as learning management systems, social media Web sites, and online virtual classrooms and environments (Huang 2019). In terms of the development of intelligent learning platform and system, it can be divided into student-oriented and teacher-oriented according to the development purpose. Eduardo Araujo Oliveira et al. (2021) and others developed personalized learning experiences for students, iCollab platform to adapt to students' preferred learning environment and respond to students' behavior, Hu (2022) have developed various learning platforms and systems to improve students' knowledge level, motivation, efficiency and satisfaction. The ITLA system, developed by Jaechoon Jo (2016) provides teachers with classroom mapping tools and real-time monitoring systems. Many research explored and designed an augmented reality (AR) environment to insights on the usability of AR technology in learning tasks, such as guiding laboratory tasks (Kapp et al., 2022), programming learning (Sunday et al., 2022). Other scholars use Raspberry Pi, artificial intelligence (Chen et al., 2022) and other technologies to build smart classrooms, smart classrooms, smart LABS and smart campuses to create a SLE for ubiquitous learning (Elgohary et al., 2022). Xie (2023) designed a preliminary online learning environment model to support teacher-student interaction in online learning contexts.

The analysis shows that the current construction of SLEs primarily focuses on the development of virtual learning spaces, such as platforms, games and systems, and often remains at the level of design frameworks, lacking practical guidance. This is because the development of platform systems has a shorter construction cycle, requires smaller investments and yields faster results compared to the establishment of smart classrooms or smart campuses. Whether it is the construction of online smart learning platforms or offline smart classroom environments, the key to building SLEs lies in enhancing student interaction, creating contextualized learning experiences and providing personalized learning approaches (Table 12.5).

Table 12.5 The construction of SLEs

Order	SLEs	Number
1	Intelligent learning platform or system	7
2	Metaverse	2
2	Smart class	2
3	Smart laboratory	1
4	Smart classroom	2
5	Smart school	5

12.4.2.3 The Research Trend on the Integration of Virtual and Physical Design of SLEs

Since the twenty-first century, the trend in learning space design has been characterized by the integration of virtual and physical elements. This trend has been primarily driven by advancements in technology and digitalization. Learning spaces are no longer confined to traditional physical classrooms but are now combined with virtual components (Ellis & Goodyear, 2016; Zhan et al., 2021).

Scholars such as Radcliffe (2009) have developed the "PST (Pedagogy-Space-Technology)" framework. Within the PST framework, technology expands the learning space, enabling the integration of physical and online learning environments. Information technology also enhances pedagogy, empowering educators to incorporate technological tools into their teaching practices. Similarly, learning spaces can influence pedagogy by providing flexible and diverse environments for various instructional activities (see Fig. 12.5).

Based on the "PST framework", many learning space design frameworks have been derived. Chinese scholars Chen et al. have proposed an "Education-Society-Space-Technology (PSST) framework" for design and evaluation (Chen et al., 2010). In contrast to the PST framework, the PSST framework emphasizes the consideration of the social dimension in learning space design. The social dimension refers to the financial resources required for constructing the learning spaces. Therefore, the PSST framework highlights the need to consider multiple factors in the design of learning

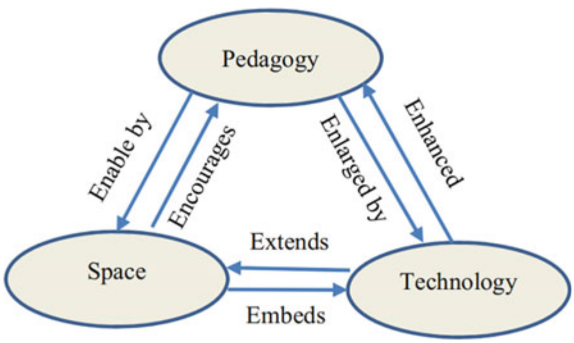

Fig. 12.5 "PST (Pedagogy-Space-Technology)" framework (Radcliffe, 2009)

spaces and analyze the relationships among these elements. This is illustrated in Fig. 12.6. Hua et al. (2017) have proposed the OPST framework based on the PST framework, emphasizing that the design of learning spaces should incorporate three dimensions: pedagogy, space and technology. Their research indicates that when designing learning spaces, it is important to meet the learners' needs and facilitate both formal and informal learning. In their study, the effectiveness of the redesigned learning spaces was validated, demonstrating that the improvements were effective. This further suggests that the OPST framework can enhance teaching and learning activities between teachers and students and improve learner outcomes to a certain extent. The specific relationships among the elements in this framework are illustrated in Fig. 12.7.

In addition, the design of the hybrid learning space that integrates the virtual and the real also needs to consider many variables, such as size, form, shape, environment setting, the technology involved, the expected activities, users and so on. Malcolm Brown and Long (2006) proposed that the design of learning spaces should prioritize learners. In their research, Young et al. (2015) highlighted the importance of designing learning spaces that facilitate student collaboration. García-Tudela

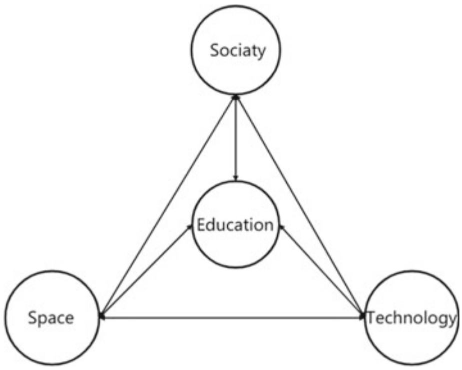

Fig. 12.6 "PSST" framework (Chen et al., 2010)

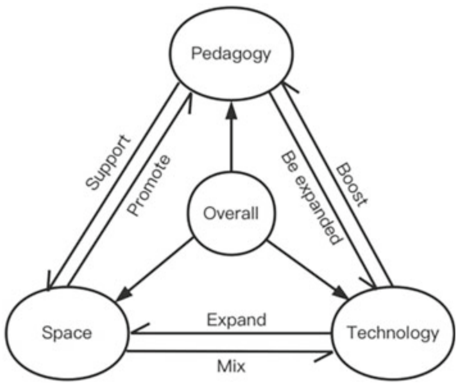

Fig. 12.7 "OPST" framework (Hua et al., 2017)

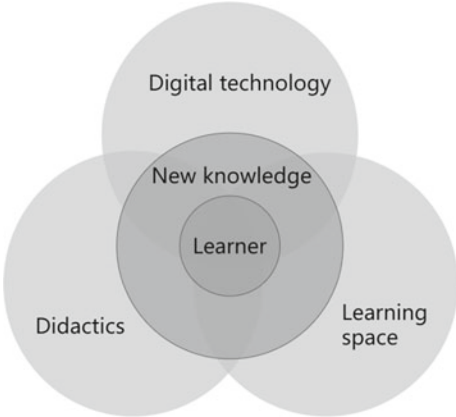

Fig. 12.8 The learning space framework in the twenty-first century (Perkins, 2010)

et al. (2021) combined virtual environment and physical environment and proposed the design model of SLE-5. SLE-5 combines virtual and physical environments so that educational agents and students can perform their communication, reflection and collaboration in an optimal manner. Therefore, it must consider the methods, assessments, technologies and spatio-temporal options that best suit students.

Perkins (2010) proposed a design framework for learning spaces in the twenty-first century, which emphasizes the importance of the synergy among instructional content, pedagogy, digital technology, and the physical and virtual learning spaces. This framework is illustrated in Fig. 12.8. On the other hand, Zeivots and Schuck (2018) designed the physical and virtual spaces based on the experiences of graduate students in learning spaces, as analyzed through survey data. In the education metaverse, Zheng et al. (2022) has fully considered the four elements of learners, its time, space and learning event, proposing a noveldata-knowledge-driven group intelligence framework, aiming to transform data into knowledge, and intersect and integrate intelligence with knowledge.

In summary, the current learning space design is evolving toward the integration of virtual and reality. In the research of learning space design for future learning, the relationship between environmental layout, pedagogy, learning resources, technical support and students should be comprehensively considered to achieve the deep integration between physical learning space and virtual learning space, so that it can better meet the needs of students and support different learning scenarios.

12.4.3 Teaching and Learning Research of SLEs

New technologies have added to the complexity of designing effective SLEs and it's necessary to require careful consideration of the pedagogy to supported learning. According to the differences of knowledge acquisition channels of middle school students in literature, the study divides the learning modes of students in SLEs

Table 12.6 The learning style of SLEs

Order	Learning style	Number
1	Collaborative learning	9
2	Gamified learning	3
3	Autonomous learning	8

into cooperative learning, gamification learning and autonomous learning (see Table 12.6).

Collaborative learning is a strategy for organizing students to learn in small groups or teams. Individual students in group collaboration activities can share the information and learning materials they explore and discover in the learning process with other members of the group, or even with other groups or the whole class. Lu et al. (2021) found that peer interaction and learning motivation directly influence students' "hotspots" of learning in smart classrooms. Hu (2022) in his study on Learning Analytics Dashboards (LAD) discovered that LAD facilitates collaborative learning among students in SLEs, helping achieve targeted instructional goals. Liu (2019) proposed a collaborative learning mechanism designed through architecture and algorithm in a web environment, enabling personalized learning resource recommendations. Ioannou et al. (2015) argued that students benefit from multimodal learning environments, where hybrid interactions can occur across physical and digital learning tools, as well as across configurations and networks of learning spaces.

Gamification learning is learning in a gamification way, which mainly includes digital games and game activities. Many empirical studies have shown that educational games and recent technologies impact education and increase learning effectiveness, students' motivation and engagement (Sunday, 2022). Teachers according to the learners' natural interest to the game psychology and curiosity about new interactive media, and the game as learners and communication platform, the process of information transmission is more vivid, thus from the traditional one-way lecturing model, the interactive elements into the communication links let learners in a relaxed, happy, positive environment for learning. Attaching importance to the cultivation of students' subjectivity and creativity is beneficial to the cultivation of students' pluralistic intelligence quality. Petrović et al. (2022) proposed a game-based IoT learning model implemented in SLEs for determining student interest, willingness to participate, and feedback on game-based learning during interactions in a smart classroom. Sunday (2022) evaluated the usability of Imikode, a virtual reality (VR) game about programming, and found that the students were satisfied with Imikode and perceived the virtual reality educational game as very useful for learning object-oriented programming concepts.

SLEs provide students with independent and personalized learning mode, which is the key to construct SLEs. Within the SLEs, students can choose and combine learning resources according to their characteristics and progress, which is conducive to improving students' learning ability. Zhan et al. (2021) found that smart classrooms significantly triggered more student-directed behaviors and student-driven teacher conversations compared to traditional multimedia classrooms, as evidenced by the increased student autonomy in smart classrooms. In addition, teachers in SLEs experimented with new teaching methods with the help of mobile devices, resulting in reduced workload and better teaching outcomes. Oliveira et al. (2021) provided an adaptive environment for students to personalize their learning through the iCollab platform. This study opens up a new possibility of incorporating students' personalities and other personal factors, such as self-regulated learning, into the design of SLEs.

Besides, a number of scholars have examined the key factors for successful implementation of smart learning in a traditional learning approach. For learners, Di et al. (2019) found that in a SLE, students' higher-order thinking is directly influenced by network attitudes and learning styles, but not by motivation to learn. Grawemeyer et al. (2017) developed an adaptive learning environment and found that affective perceptual support helped to reduce feelings of disinterest and learning irrelevant behaviors, emphasizing that perceptual models play an adaptive transfer of formative feedback for learning play an important role in the adaptive transfer of formative feedback for learning. For teachers, Ha and Lee (2019) identified teachers' educational beliefs as a key factor in the successful implementation of smart learning, and teachers who were student-centered and had a high level of ICT-related knowledge were more supportive of smart learning. Neither teachers' nor learning participants' gender had a significant effect on the preference for SLEs (Grawemeyer et al., 2017).

The analysis shows that the SLEs mainly focus on students' cooperative learning and autonomous learning, that is, SLEs create conditions for students' cooperative learning and autonomous learning (Gambo & Shakir, 2021a, 2021b). Learning analysis technology and learning perception technology provide personalized guidance, real-time feedback and help for learners, such as matched learning resources, learning paths and learning methods, so as to promote the generation of students' collaboration and autonomous learning. However, the traditional learning approach still exists in the SLEs. Teachers do not make full use of the SLEs to guide students' communication and learning, and do not break the traditional rigid model, which limits the role of the SLEs in the teaching field (García-Tudela et al., 2021).

12.5 Discussion and Implications

The purpose of this review is to explore how to use technology to design SLEs and the learning methods in SLEs based on the understanding of international SLEs research status. The results show that the international studies on SLEs mainly focus on five aspects: technical support of SLEs, model construction of SLEs, assessment system of SLEs, teaching and learning of SLE and design of SLEs. Most of them focus on the technical support and design of SLEs.

Related literature on the function of technology in SLEs all prove that the application of technology in SLEs can achieve better efficacy. It can sense students' emotions and fatigue levels to provide students with appropriate learning strategies, dynamically predict learning paths and support collaborative learning. The research on the construction of SLEs mainly focuses on the construction of intelligent learning platform or system (Estrada et al., 2020; Radosavljevic et al., 2022). At the same time, the latest developments in augmented reality, rich media technology, sensor technology, learning analytics and other technologies offer the possibility of building learning spaces that combine physical and virtual vice.

Analyzing research related to the construction and design of SLEs, the trend of learning space construction is to achieve effective integration of physical space and virtual space in educational institutions. For schools, physical learning spaces include formal learning places such as classrooms, laboratories, multimedia rooms (Zheng et al., 2022) and many informal learning places such as libraries, study rooms and gymnasiums. Virtual learning spaces, on the other hand, include various learning management systems, learning resource platforms, social networking platforms (Strayer, 2012; García-Tudela et al., 2021). The purpose is to provide a unified and friendly interface for learners to be able to go deeper with simple and natural interactions. The integration of physical space and virtual space is the goal of learning space construction. Taking the classroom as an example, the configuration of high-definition camera, broadband network and multi-screen touchpad enables teachers and students in different areas to achieve the same real-time interaction as face-to-face effect in the physical classroom environment, using the hybrid synchronous network end classroom to achieve and surpass the effect of the real physical classroom, truly realizing the integration of physical space and virtual space (Martín et al., 2022). In addition, the construction of learning spaces should take into account the group learning characteristics of the new generation of digital natives, creating environments that support students' collaboration with each other, facilitate easy access to the Internet and promote authentic learning, while respecting students' individual needs and promoting adaptive and personalized learning (Kubsch et al., 2022; Oliveira et al., 2021).

Teaching and learning under SLEs' research find that the learning modes under SLEs are mainly cooperative learning, gamification learning and autonomous learning, which reflect the characteristics of SLEs and its value to students (Pérez-Escoda et al., 2021). The study also proves that the SLEs have a positive effect on both teachers' teaching and students' learning. Some studies have found that SLEs improve students' interest in class and reduces teachers' work burden when evaluating teachers' and teachers' satisfaction (Dai et al., 2021; Hu, 2022). The design of the learning space should take into account the pedagogy and be able to be flexibly adjusted and changed according to different pedagogies, and should be able to support classroom lecture, independent, inquiry and collaborative learning, as well as outdoor mobile learning and ubiquitous learning. Taking the classroom space as an example, the seating layout in the classroom can be adjusted to the typical "seedling type" to support the teaching method of lecture, and the seating layout in the classroom can be adjusted to the "multi-group round table type" to support the teaching method of inquiry and collaboration (Cebrián et al., 2020; Zhan et al., 2021). The classroom space can provide an SLE that simulates real-life situations, where students can use various digital resources and rich tools to conduct research, discuss according to the problems, interact easily with local or remote teachers and classmates, and display the learning results flexibly to the whole class (Mircea et al., 2021; Tissenbaum & Slotta, 2019).

12.6 Conclusion and Recommendations for Future Work

This study employs a literature review method, specifically analyzing the literature on SLEs in the Web of Science database. The distribution of studies (publishing year, country and journal), the design of learning spaces and learning ways of technology-supported SLEs are summarized in this paper. SLEs is a globally recognized research field with a rapid increase in publication volume in 2022. The contemporary studies focus on five key areas: technical support for SLEs, the design of learning spaces, teaching and learning ways in SLEs, SLE models and assessment of SLEs' quality. Most of these studies focus on the first two. Research of SLEs mainly focuses on software devices development and virtual learning spaces design, like the smart learning systems, platforms for technical support, and the construction of games, systems and metaverse, with limited attention given to hardware devices and physical learning spaces. The design of learning spaces is trending toward integrating virtual and physical elements. Learning ways in technology-supported SLEs focuses on cooperative learning and autonomous learning. However, most studies often remain at the level of design frameworks, lacking practical guidance.

In today's world, technology plays a significant role in shaping and enhancing the learning experience. Although there have been remarkable advancements in learning technologies and learners' ability to adapt to their evolving surroundings, technology is often seen as a supplementary tool rather than a driving force in the learning environment (Singh, 2022). Therefore, in addition to supporting related research, experts and scholars have focused their work on effective SLEs design. The trend of designing and practicing blended learning environment in a wider range of application fields has emerged, including the characteristics of learning environment, teaching technology support, relevant teaching methods, implementation and evaluation (Thomas et al., 2019).

New technologies have added to the complexity of pedagogical design in SLEs. With the incorporation of technology, physical learning spaces are connected to online learning spaces. When teaching in these spaces, utilizing relevant information technology and considering instructional approaches in conjunction with teaching content is essential. Furthermore, SLEs should support various learning scenarios, including formal and informal learning.

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Chapter 13
Future Campus Design in the Digital Transformation of Education: Conceptual Model and Solutions

Yunwu Wang and Hamad Adil

Abstract What the future campus will look like, whether it will disappear, and how to plan and design the future campus are topics of great concern to people. This chapter aims to creatively propose the concept, key supporting technologies, principles and methods of planning and design, and typical cases of future campus design in response to the practical demands and ability demands of future talent cultivation. The detailed content includes education model of future campus, future smart learning space, concept, and connotation of future campus, planning and design of the future campus, the key technologies for future campus construction, and the construction cases of future campus. This article will discuss several questions about the future campus, such as why to design, what to design, how to design, and design suggestions.

13.1 Introduction to Future Campus Design

13.1.1 Background for the Emergence of Future Campus

As society transitions into the era of smart technology, there are increasing expectations for enhanced learning environments within schools. The campus needs to be redesigned under the background of digital transformation of education, cultivation of innovative talents, and development of intelligent technology.

13.1.1.1 Digital Transformation of Education

In recent years, the proportion of the global digital economy to gross domestic product (GDP) has continued to increase, and the digital industry is driving the

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transformation of the world economy. Actively embracing the significant opportunities of a new round of technological revolution and industrial transformation is becoming a common strategic choice for many countries around the world. Driven by multiple factors such as the digital economy, digital industry, and technological revolution, the global digital transformation has accelerated. People are forced to improve their digital literacy and skills to meet the practical needs of digital transformation in various industries. Digital survival in a smart society (i.e. digital intelligence society) is becoming a basic social survival state for people. In order to better welcome the arrival of a smart society, people need to develop the habits of digital learning, digital work, and digital life as soon as possible. Under the influence of multiple factors such as the rapid development of intelligent technology, the two-way empowerment of science & technology and education (Huang et al., 2021), and the practical demands for the future development of education, the digital transformation of education is becoming a new trend in the development of future education. People's attention to digital transformation is showing explosive growth, and more and more economies around the world are accelerating the implementation of digital transformation strategies in education. The digital transformation of education is also aimed at better achieving the strategic goals of the *2030 Agenda for Sustainable Development*, ensuring inclusive and fair quality education, and providing lifelong learning opportunities for all (Goal 4).

The digital transformation of education is still a new thing, and people are particularly unable to accurately understand the connotations and relationships of related terms such as educational informatization (i.e. ICT in education), digital education, and smart education. The result of educational informatization is the formation of information-based education, the result of educational digitization is the formation of digital education, and the result of educational intelligence is the formation of smart education. Digital education can be understood as the result of the development of educational networking and digitization. It is an advanced stage of educational informatization development and a necessary stage of educational intelligence, with the ultimate result of moving towards smart education.

The digital transformation of education is a state, not a result. The digital transformation of education includes the digital transformation of traditional education and the education industry, which can be seen as the only way to achieve smart education. The essence of digital transformation in education is to promote systematic changes in education and promote the formation and development of a smart education ecosystem. The strategic value of digital transformation in education is to accelerate the development of educational informatization and promote high-quality development of education through educational informatization. The key to the digital transformation of education is to solve the difficulties and pain points in the process of educational informatization, promote the high-quality development of educational informatization, and accelerate the implementation of smart education. The digital transformation of education refers to the digital transformation of all elements, processes, businesses, and fields of education, using intelligent technology to transform the education system and promote the formation and development of a smart education ecosystem. Its fundamental purpose is to cultivate innovative talents required for the development of the digital economy and smart society.

13.1.1.2 New Demands for Future Talent Cultivation

From the information society to the smart society, especially under the influence of intelligent technology, two important changes are taking place in the human profession. One is that traditional human professions are accelerating their disappearance. For example, the American Association of Retired Persons (AARP) has listed 20 professions such as locomotive firers, respiratory therapy technicians, and parking enforcement workers that may disappear forever (Kenneth, 2020), while the Irish career website has listed 15 professions such as travel agent, cashier, and fast-food cookie that will not exist by 2030 (Siôn, 2021). Another phenomenon is that human new occupations are accelerating to emerge. For example, according to the statistics of the 2022 edition of the *Occupational Classification System of the People's Republic of China* issued by the Ministry of Human Resources and Social Security of the People's Republic of China, China has a net increase of 158 new occupations.

Currently, artificial intelligence is replacing some people's work, and virtual digital humans are increasingly possessing a certain degree of creativity. Especially with the emergence of ChatGPT (Chat Generative Pre-trained Transformer), there has been a great discussion about whether artificial intelligence can replace humans in the future. The extent to which artificial intelligence replaces humans depends on its functionality and value. The essence of artificial intelligence determines its function and value. Artificial intelligence is the imitation, extension, and expansion of human intelligence, which allows machines to possess consciousness, thinking, abilities, and attitudes like humans, and its highest level is the wisdom of the owner. The key to the evolution of humans into advanced organisms lies in the evolution of the brain, which gave humans wisdom. If artificial intelligence completely replaces humans, it requires precise imitation, and even extends and surpasses human intelligence. However, brain science is both a cutting-edge academic research field and a global challenge, and has not yet achieved significant breakthroughs in supporting artificial intelligence. The plasticity of the human brain exceeds human imagination. Under current technological conditions, artificial intelligence imitates, extends, and surpasses human intelligence, which is a global challenge.

The problems that artificial intelligence can solve can be divided into three categories: problems that have already been solved, problems that are being attempted to solve, and problems that can be solved in the future. Artificial intelligence cannot completely replace humans, it can only replace some of their work. The Four Quadrants of Artificial Intelligence Replacing Humans, as shown in Fig. 13.1. Complex and low value-added physical labor is easily replaced by artificial intelligence, while mental and emotional labor are more difficult to replace by artificial intelligence. Creative and high value-added innovative labor is the most difficult to replace by

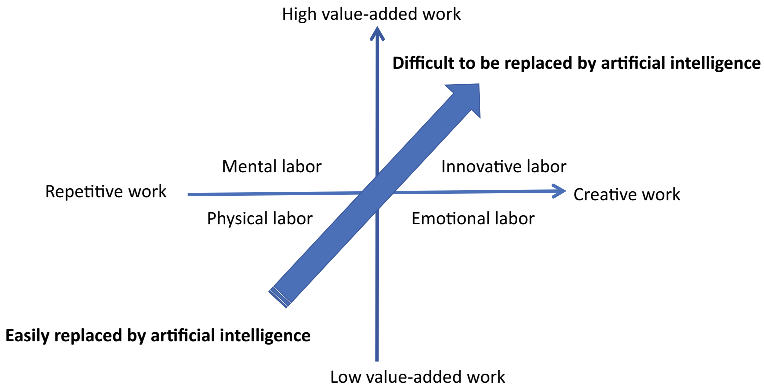

Fig. 13.1 The four quadrants of artificial intelligence replacing humans

artificial intelligence. The more repetitive, low value-added, and lack of creative innovation work, the easier it is to be replaced by artificial intelligence.

What abilities future talents should possess has become a question that talent cultivation has to consider. In a smart society where new and old professions are rapidly changing, future talents need to urgently enhance their abilities in problem-solving, self-management, collaborative work, digital literacy, and skills. Future talents also need to be able to actively use digital tools and software for flexible learning, while increasing resilience and stress resistance. Future talents should be digital learners, and more importantly, they should become digital creators. As an important venue for cultivating innovative talents required for a smart society, schools must be redesigned for the future to meet the needs of cultivating innovative talents. Education needs to face the future and cultivate innovative talents that are suitable for the era of intelligence.

13.1.1.3 New Forms of Future Education in the Intelligent Era

The learning environment is highly consistent with the level of education, economy, and social development, and the rapid development of education, economy, and society in the new era has generated new demands for the learning environment. The two-way empowerment of science and technology and education has accelerated the reshaping of future educational forms, and new educational forms need to have a corresponding future school environment.

Future education presents new forms of smart education such as large-scale teaching and personalized talent cultivation, flexible teaching and self-learning, short video + live streaming education, mobile online education, and online-merge-offline (OMO) education, which puts higher requirements on the smart learning environment. The new form of smart education in the future needs to reshape the smart learning environment.

As humanity enters the era of interconnected intelligence, the new "normal" of future education will reflect the characteristics of mutually beneficial coexistence of flexible teaching and active learning. Flexible teaching time and space are the basic symbols of future education, and diverse learning methods and evaluations are the basic characteristics of future education.

With the widespread use of mobile terminals, learning and teaching have broken through the limitations of media and terminals, and mobile online education is becoming a new form of online education development. Mobile online education is a new form of online education that utilizes intelligent mobile terminals such as smartphones and tablets to easily access adaptive digital learning resources, supported by the integration of multiple networks, and supports flexible teaching and autonomous learning. Mobile online education is gradually penetrating into a wide range of learning fields. Short video + live streaming education, with its fun and "short and fast" characteristics, caters to the needs of fragmented learning and is favored by learners. It is becoming an important informal learning method, providing a new way for large-scale and personalized education. The rapid development of mobile online education has accelerated the integration of online-merge-offline (OMO) education.

With the widespread popularity of F5G all-optical network and WiFi6, it will promote the construction of a true era of intelligent interconnection of all things based on 5G + F5G + WiFi6, and vigorously expand many application scenarios. Currently, many 5G application scenarios have emerged in the field of smart education, including 5G-enabled VR virtual training, 5G-enabled dual-teacher classrooms, 5G-enabled ecological classrooms, 5G-enabled smart classrooms, and 5G-enabled ubiquitous learning.

The future of smart education will reshape the smart learning environment through intelligent technology, achieving a high degree of integration between physical and virtual environments; Innovate new teaching models to achieve the integration and development of large-scale education and personalized teaching; Construct a modern education system that matches the era of intelligence, establish an innovative talent training system, promote balanced and high-quality development of education, and nurture human "wisdom". Smart education, intelligent education, future education, smart campus, future campus, etc. will be high-frequency terms in the field of education in the intelligent era.

13.1.2 Overview of Future Campus

13.1.2.1 Transition of Human Learning Environment

The learning environment is not only a place for disseminating educational information and nurturing human education, but also a space for inheriting human civilization and inspiring human wisdom. The learning environment can be seen as the sum of internal and external conditions under which learning activities occur, playing an extremely important role in human education. The learning environment consists of two types: original ecological learning environment and artificial learning environment. The basic forms of learning environment can be divided into family learning environment, social learning environment, and school learning environment, all of which are typical artificial learning environments. The school learning environment refers to smart schools, smart campuses, future schools, future campuses, etc.

The history of human education development contains historical changes in the learning environment. From the perspective of human civilization, human learning environments can be divided into five types according to their environmental forms: scene, learning environment, digital learning environment, smart learning environment, and ubiquitous smart learning environment. Under the influence of concepts such as smart earth, smart country, smart city, and smart education, the learning environment has accelerated the transition from a digital learning environment to a smart learning environment, showing a trend of intelligent and smart transformation. As a high-end form of digital learning environment development, smart learning environment plays an increasingly important role in promoting changes in learning, teaching, and management methods. Intelligent technology further promotes the transformation and upgrading of smart learning environments, and ubiquitous smart learning environments will become a new trend in the development of smart learning environments. Especially with the support of 5G, F5G, and WiFi6, smart learning environments have emerged with four significant features: intelligent interconnection, borderless, ubiquitous, and high-speed. The ubiquitous smart learning environment is based on new generation intelligent technologies such as mobile internet, tactile internet, artificial intelligence, blockchain, etc., promoting a shift from knowledge dissemination, knowledge sharing, and knowledge consumption to knowledge creation, meeting learners' personalized, diversified, and intelligent needs, and creating a virtual and real learning space with high experience and satisfaction.

Looking back at the entire history of human development, it can be seen that the learning environment has undergone changes from openness to closure, and then to ubiquitous. The human learning environment has moved from the wild to the indoor, and then towards borderless, campus, and outdoor integration, as well as online and offline integration. In the process of human civilization, new concepts, theories, media, and technologies are the fundamental forces driving the changes in the learning environment, which is a process of continuously meeting the new demands of education, economic, and social development.

13.1.2.2 Definition of Future Campus

The future campus, also known as the future school, is a new form of school in the context of digital transformation. Similar terms to future campus include digital campus, intelligent campus, and smart campus. Future campus emphasizes future-oriented education and talent cultivation, while smart campus emphasizes the intelligent characteristics of the campus and pay more attention to the intelligence of media, technology, resources, means, and methods.

The future campus is guided by the concept of design thinking and comprehensively utilizes intelligent technologies such as 5G, F5G, WiF6, and artificial intelligence to design a future learning environment for cultivating innovative talents in the intelligent era.

In order to better understand the future campus, the conceptual model of the future campus can be analyzed, as shown in Fig. 13.2.

The design of future campuses should follow the following five principles: Innovation and creativity, Green and environmentally friendly, Health and safety, Intelligent interconnection, Boundless and ubiquitous.

According to design concepts, future campus design can usually be divided into five categories: Future campus design centered on environment, Future campus design centered on current curriculum, Future campus design centered on student, Future campus design centered on smart services, and Future campus design centered on knowledge innovation.

The planning and design of coming to campus generally need to consider: Design framework for future campus, Design of future classroom, Design of future library, Design of future learning center, and Design of future dormitory.

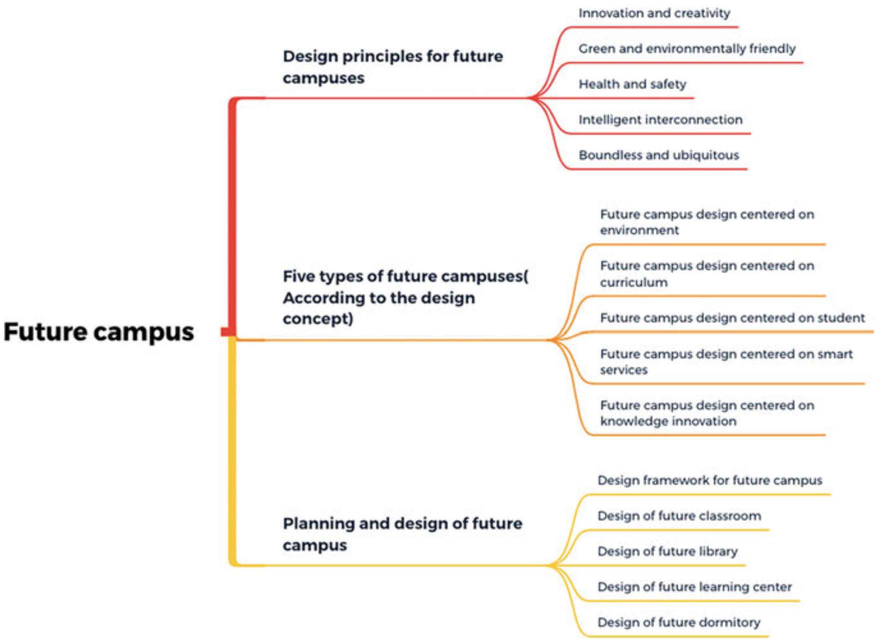

Fig. 13.2 Conceptual model of future campus

13.1.2.3 Characteristics of Future Campus

The future campus has 8 characteristics:

(1) Highly intelligent (highly smart) refers to the significant improvement in the overall level of intelligence in the future campus. Compared to explicit intelligence, the proportion of implicit intelligence and innovative intelligence has significantly increased.
(2) High sense of experience and satisfaction, that is, significantly improving the level of smart education services, allowing teachers, students, and parents to obtain the best sense of experience and satisfaction.
(3) Intelligent interconnection (smart interconnection) refers to the deep integration of information, data, business, applications, and services through the intelligent interconnection of networks, media, technology, platforms, resources, data, people, and things.
(4) Ultra high speed network, utilizing 5G, F5G, WiFi6, and other technologies to build intelligent and interconnected ultra high speed communication networks. Especially with the support of mobile internet, building a new generation of mobile smart campus.
(5) Intelligent analysis refers to the use of artificial intelligence, big data, blockchain, and other technologies to achieve intelligent visualization analysis of various business data, serving smart learning, teaching and management, and serving the reform of education evaluation in the new era.
(6) Smart decision-making refers to serving smart decision-making through internet public opinion monitoring systems, intelligent decision support systems, etc., in order to enhance the modernization level of educational governance.
(7) Systematic transformation in education refers to the transformation of learning methods, teaching methods, management methods, governance methods, and other aspects supported by intelligent technology, reshaping the new form of future campus, triggering qualitative changes through quantitative changes, and ultimately promoting the overall transformation of the education system.
(8) Innovation leadership refers to achieving the highest level of "smart" in the future campus—innovative wisdom. Through innovative wisdom, education innovation, and change are led, supporting the cultivation of innovative and intelligent talents in the future.

13.2 Related Research and Cases on Future Campus Design

13.2.1 Related Research on Future Campus Design

Currently, the future campus is still a forward-looking study, and there is relatively little research on the future campus. From a practical perspective, more and more schools are starting to build future campuses to meet the needs of future education and talent training. From the perspective of academic research, future education, future campuses, future schools, future classrooms, future learning spaces, future teachers, and future learning and teaching methods are becoming emerging research fields.

Since 2013, the China National Academy of Educational Sciences has initiated theoretical research and practical exploration of the "Future School", focusing on how to build a future school, including the training objectives, curriculum construction, organizational structure, and spatial design, as well as the development model and ecological construction of future schools. In addition, China has also published works such as "Future Schools: Redefining Education" and "Future School Learning Space".

Deloitte (2019) proposed the concept of the next generation connected campus (i.e. smart campus), with a design framework including smart student, smart classroom and lab, smart teaching and research, and smart student administration, smart housing and dining, smart mobility, smart events, smart operations, smart stadiums, etc.

In 2021, the European University Association (EUA) issued the "*University Without Walls - Vision 2030*" (European University Association, 2021), which sets out the goals that European universities hope to pursue together: openness, sustainability, and autonomy. Universities without walls will leverage the opportunities brought by digitization to create connections between reality and virtual reality, in order to construct research and learning environment that can meet the diverse needs of universities. Sustainability is the most critical feature of a university without walls, and universities aim to make sustainability an important component of their learning, teaching, research, innovation, and cultural mission.

13.2.2 Related Cases on Future Campus Design

13.2.2.1 Smart Campus Enabled by 5G Technologies

With the gradual application of emerging technologies such as 5G/AI/big data in the smart campus, the school's digital transformation has increasingly become a new trend of the future campus. As a result, there are many new applications in smart campus, such as dual-teacher classroom, live classroom, smart classroom, intelligent assessment, virtual and simulation experiment, green campuses, and school administration.

In September 2021, the Ministry of Industry and Information Technology and the Ministry of Education of China launched the "*5G enabled Smart Education*" *Application Pilot Project*. The project mainly focuses on five aspects: 5G-based interactive teaching, 5G empowered security on examination, 5G-enabled multimodal evaluation, 5G-enabled smart campus, 5G enhanced regional education decision-making. In the future, it is suggested to accelerate the adoption of 5G, WiFi6, AI, IoT, and other technologies to promote the development of smart education.

5G has the potential to change the smart campus in the future, which could be used to create a smart environment that improves the experience of students and staff. The school usually leverages 5G to adequately support the coverage of very large outdoor areas across many buildings throughout the campus. There are many 5G-based business applications in smart campus. In co-taught classes, Ultra HD video and course materials can be transmitted to remote classrooms simultaneously through 5G networks.

13.2.2.2 Utilizing a Comprehensive Learning Space to Achieve Immersive Learning

In response to the dilemma of limited educational space, Shanghai Qisehua Primary School has created a comprehensive learning space with diverse functions and environments based on the needs of learners, skillfully utilizing information technology and multi-dimensional contexts.[1] In a space of only 400 square meters, the deep connection between space technology, curriculum teaching, and people has been achieved. The three structures of physical space, social space, and mental space are unified, and a future education space connecting virtual and real worlds has been created based on data and open resources.

The learning space can achieve an immersive learning experience in sound, light, and shadow based on the fusion of physical and virtual spaces such as scenes and data, according to the needs of teaching scenarios in different disciplines such as sports, English, and science. This learning space focuses on addressing the constraints of existing learning spaces on future education and even talent cultivation, reflecting the new demands of the new era for learning spaces and the characteristics of modern learning spaces that are reusable, immersive, intelligent, and intelligent. In the process of building a learning space, a multi-dimensional integrated environmental paradigm, a technology-enabled teaching paradigm, and a multipoint integrated curriculum paradigm have been explored and formed, achieving significant results in promoting curriculum leadership improvement, supporting interdisciplinary learning, and reforming teaching and learning methods.

[1] The case of Shanghai Qisehua Primary School, "Magic Space: Construction and Practice Research of School Comprehensive Learning Space," won the first prize in the 2023 Global Competition on Design for Future Education.

13.2.2.3 Small Scale, Project-Based Collaborative Courses

The Franklin W. Olin College of Engineering, established in 1997, is a very small college but enjoys a high reputation in engineering education. As a leader in the transformation of engineering education, the College's innovations and contributions are now recognized globally. As the College prepares to dive into an impact-centered curriculum that offers more transdisciplinary, real-world educational experiences to students, and prepares and inclines graduates to serve people, society, and the planet (Franklin, 2022). The curriculum emphasizes the practicality of knowledge and interdisciplinary learning, emphasizes practical education, and strengthens the integration of knowledge with challenges and topics in real life. Enhancing skills through practical exploration and understanding the theories through concept-based practice. Self entrepreneurship is the goal of many students at the Olin College, and according to statistics, 39% of alumni have been involved in a startup venture.

13.2.2.4 Future Learning Center Enabled New Paradigm for Education

With the development of intelligent technology, learners' learning methods, thinking patterns, and their needs for the learning environment are quietly changing. Schools need to address the new needs of learners, upgrade smart learning services, and build several future learning centers that meet their personalized needs. The Future Learning Center is a new type of intelligent learning space constructed through spatial process reengineering, with the support of intelligent technology, aimed at cultivating future innovative talents. The future learning space can support various learning methods such as team learning, collaborative learning, thematic learning, and scenario learning. It is not only a learning support service center, but also an innovation and creativity center. Its fundamental purpose is to reshape a new smart learning environment, change traditional learning methods, reform traditional talent cultivation models, and explore new paradigms for education in the new era.

Learning Hub in Nanyang Technological University

The learning hub of Nanyang Polytechnic University in Singapore is a multifunctional building that can accommodate 33,000 students, redefining a creative teaching building (E-architect, 2015). Twelve towers gradually converge towards the bottom, orderly surrounding a huge atrium space, providing 56 classrooms with no corners or clear front and rear distinctions. The concrete core of the staircase and elevator has 700 specially designed patterns, covering various disciplines such as science, art, literature, etc. The temperature in Singapore remains between 25 and 31 °C year-round, and the spacious and transparent atrium of the building serves as a natural ventilation outlet, maximizing the circulation of air around the tower classrooms and making students feel as cool and comfortable as possible.

Future Learning Center Based on Learning Style Scenarios

The future learning center needs to meet the needs of teaching, experimentation, and diversified learning in the discipline. According to different learning methods and scenarios, future learning centers can be divided into collaborative learning centers, immersive learning centers, project-based learning centers, and so on (SEEWIN, 2020). The Collaborative learning center focuses on promoting collaborative learning and building a learning space for learners to facilitate dialogue, discussion, and debate. The immersive learning center utilizes VR, AR, MR, holographic technology, and other technologies to create a learning environment that approximates real situations for learners, allowing them to gain an immersive learning experience in a highly interactive virtual real fusion environment. Project-based learning centers typically revolve around challenging projects, providing learners with a wealth of key equipment, materials, etc., allowing them to actively explore real-world problems by completing projects.

13.2.2.5 From "Transparent" Classrooms to Open "Learning Space"

The cultural space design of Shenzhen Luohu Future School is very unique and has won the "International Space Design Award IDEA-TOPS" (Shenzhen News Network, 2023). The construction process of the school follows the path of "concepts first, followed by design, followed by architecture, and finally education". The school does not have a fixed class and grade division, promoting mixed-age teaching and interdisciplinary teaching. There is no traditional classroom, but instead a "learning space" that integrates virtual and real life is constructed using high-tech methods such as intelligent IoT, big data, and holographic imaging. This is also a space for learners to share, communicate, practice, and operate.

13.3 Findings and Design Solutions on Future Campus Design

13.3.1 Design Theory of Smart Learning Environment

Looking back on the research process of smart learning environment, analyzing the construction practice of smart learning environment, and sorting out and discovering that the construction of smart learning environment has ten important theoretical foundations:

13.3.1.1 Design Thinking Theory

The planning and design of a smart learning environment is a complex process that typically includes user needs analysis, comparative analysis of environmental design solutions, brainstorming and creative design, and the formation of design solutions. Design thinking can be flexibly applied to every aspect of planning and designing smart learning environments, providing a creative source for reshaping smart learning environments. The application of design thinking can enhance the creativity of environmental design, and innovate the design of a smart learning environment that combines practicality, comfort, and artistry. A smart learning environment is an important place to provide learning services for learners, and the use of service design thinking can provide reference and inspiration for campus service environments.

13.3.1.2 Emotional Design Theory

In the field of design, designers often pay great attention to the practicality and ease of use of products, and rarely pay attention to the emotional interaction between people and products. Regardless of physical learning environments such as smart classrooms and libraries, as well as software and websites, the environment and products subconsciously affect people's emotions. The architectural environment, campus landscape, smart furniture, and new media are being influenced by emotional design theory and integrated into it. The emotional design of the environment is based on the basic understanding that the source of happiness is the palpitations of the soul, focusing on communication and a sense of activity. Integrating emotional design concepts into a smart learning environment can provide learners with a positive emotional experience, thereby helping to achieve better learning outcomes.

13.3.1.3 Theory of Human–Computer Interaction

Compared to digital learning environments, smart learning environments have strong human–machine interaction, human–human interaction, and machine–machine interaction relationships, especially highlighting the characteristics of human–machine integration. The human–machine interaction technology, human–machine interaction models, and human–machine interaction based on data gloves, tactile sensors, and skill sensors in virtual learning environments urgently require in-depth research. In the future, eye control interaction technology, somatosensory interaction technology, VR/AR/MR interaction technology, bone conduction interaction technology, brainwave interaction technology, skill interaction technology, etc. will become the forefront research fields of human–computer interaction. The construction of a smart learning environment requires attention to human–computer interaction, and planning and design based on experience to increase the effectiveness of human–computer interaction and enhance the smart learning experience.

13.3.1.4 Activity Theory

Teaching is composed of several learning and teaching activities, which play an important role in promoting the internalization of learners' knowledge and skills. The construction of a smart learning environment needs to reflect the concept of activity centeredness in order to effectively support the dominant subject teaching model. Learning activity design needs to focus on six basic links, namely demand analysis, learner focus, learning scenario design, providing necessary technical environment, constraint analysis, and learning support service design. Activity theory can serve as a guiding framework for instructional design, and the creation of a smart learning environment needs to fully consider the practical needs of conducting various learning activities such as exploratory, project-based, and collaborative. Whether it is a real learning environment, online learning environment, virtual learning environment, simulation learning environment, etc., it is necessary to fully consider the practical needs of learning and teaching activities in planning and design.

13.3.1.5 Immersion Theory

When people engage in learning activities in a learning context, focusing their attention can achieve a state of immersion and achieve a higher sense of immersion experience. Immersion is a state often present in virtual interaction, and immersion and interaction have a significant impact on learners' learning. The virtual simulation learning environment creates a sense of immersion, enhances learners' sensory and cognitive experiences, helps to enhance learners' interest in learning, and enhances their embodied and situational cognition. The tactile internet and skill internet extend human skills, and the five major scenarios of future tactile education robots, online real-time skill learning, remote tactile experiments and experiences, blind tactile compensation, and tactile feedback learning environment based on embodied cognition have put forward higher demands for creating immersive learning. The metaverse represents the latest stage in the development of visual immersion technology, which has undergone four stages: desktop virtual reality, immersive virtual reality, extended reality, and metaverse. The learning environment based on the metaverse will achieve a high-end form of immersive learning experience.

13.3.1.6 Theory of Embodied Cognition

In recent years, under the influence of embodied cognitive theory, embodied learning has attracted academic attention as a cognitive approach deeply influenced by the learning environment. Creating an embodied cognitive learning environment requires the use of embodied technology to provide rich perceptual experiences, allowing learners to learn from various types of learning resources. The embodied cognitive learning environment mainly consists of four parts: physical environment, social and cultural environment, resource support environment, and emotional and psychological environment. The development of technologies such as artificial intelligence, big data, robotics, AR/VR/MR, and tactile sensing has provided technical support for creating an embodied cognitive learning environment.

13.3.1.7 Distributed Cognitive Theory

The distributed cognitive theory believes that cognition is distributed among individuals, groups, and artifacts. Distributed cognition can provide a theoretical framework for designing intelligent learning environments. Learner cognitive activities are distributed among the components of smart learning environments such as learners, media, resources, atmosphere, and culture. The intelligent learning environment is a typical artificial product, and the appropriate use of intelligent products can promote learners' distributed cognitive activities.

13.3.1.8 Situational Cognitive Theory

Situational cognition is an important perspective that can provide meaningful learning and promote the transformation of knowledge into real-life situations. The theory of situational cognition holds that learning activities occur in real situations, and learners are influenced by the situation and interact with the learning environment to achieve the learning effect of reorganizing old and new knowledge. From the perspective of situational cognition theory, smart learning environments require the construction of real learning contexts that are conducive to improving learning experiences and enhancing learning outcomes. Currently, both real-life learning environments and virtual simulation learning environments are applications of situational cognition theory in intelligent learning environments.

13.3.1.9 Cognitive Load Theory

The cognitive load theory has become one of the most influential theoretical frameworks in the field of learning and teaching, and has gone through various stages of development, including cognitive theory of multimedia learning, cognitive affective theory of multimedia learning, and cognitive affective integration theory of multimedia learning. The transformation of learning environment and learning methods has become an important proposition of the times. To construct a complex intelligent learning environment using intelligent technology, it is necessary to fully consider the cognitive load of learners. The planning and design of smart learning environments should reduce learners' cognitive load, rather than increase learners' cognitive load.

13.3.1.10 Architectural Color Visual Modeling Theory

The visual modeling theory of architectural color is an important guiding theory for architectural color design. In the design of architectural colors, it is necessary to apply the theory of visual modeling of architectural colors to handle the relationship between visual modeling of architectural colors and visual modeling, as well as the environment and people. Color can create psychological experiences for people, and architectural color design needs to fully consider the influence of many environmental factors. The appropriate application of color visual modeling theory by designers can enhance the psychological experience of the physical space in smart learning environments.

13.3.2 Key Technologies for Future Campus

Currently, biotechnology, neural technology, nanotechnology, new energy, information, and mobile technology are showing exponential growth, and the new generation of information technology represented by artificial intelligence is redefining the value of human knowledge and capabilities. Technology, as an advanced productive force, plays an important role in the field of social production. Every major technological invention and improvement of labor tools will trigger a revolution in the field of social production. From early audio and video, multimedia technology to modern computers and information technology, to today's 5G networks, big data, blockchain, educational robots, virtual reality, artificial intelligence, etc., technology is playing an increasingly important role in the development of education and becoming an important driving force for promoting educational reform and development.

5G supports intelligent interconnection of all things, which helps reshape the education network environment and enables full connectivity between people, people and things, things and things, fundamentally changing the current education model. Big data technology can drive the precision of education governance and evaluation, promote precision teaching, and become an innovative driving force for the new round of education reform and development. By utilizing blockchain technology, a secure and trustworthy education system can be built, thereby strengthening intellectual property protection, effectively managing academic certificates, and driving precise evaluation of education. Educational robots are representative of the application of robots in the field of education, and are typical examples of the application of artificial intelligence, speech recognition, and biomimetic technology in education. Virtual reality technology shapes immersive interactive learning experiences, which can generate the feeling and experience of being in the real environment firsthand. Artificial intelligence has been regarded as one of the main core technological forces driving the progress of modern society, and is being integrated into school education to change the teaching and learning methods of teachers and students.

13.3.2.1 5G Supported Intelligent Interconnection of All Things

The advent of 5G era will make the future education development face new challenges and opportunities 5G technology reshapes the ultra high speed network environment and promotes the interconnection of all things. 5G has the versatility of high reliability, low power consumption, low delay, large capacity, large coverage, and large connection (one high, two low), which improves the quality of network education and reduces the threshold. It can realize the full connection between people, people and things, and things, which will fundamentally change the current education mode. The rapid development of 5G technology and industry has laid the foundation for vigorously promoting “5G + education” and brought new opportunities and challenges to education and teaching forms and educational service formats. 5G technology helps to reshape the educational network environment, will expand our current “Internet plus education” advantages, realize the interconnection of all things, significantly enhance the level of educational intelligence, and promote the optimal allocation of educational resources.

13.3.2.2 Big Data Technology Drives Educational Governance and Accurate Evaluation

Big data technology is conducive to promoting the accuracy of educational governance and evaluation. Big data is a data collection characterized by huge volume, various types, fast access speed, and low-value density. Promoting educational reform and innovation based on big data technology has become the development trend of the times. The key technologies of educational big data mainly include four categories: educational data mining technology, learning analysis technology, data visualization technology, and decision support technology. Big data technology can drive the accuracy of educational governance and evaluation and promote accurate teaching. Education big data will become an innovative driving force driving a new round of education reform and development.

13.3.2.3 Building a Completely Credible Education System with Blockchain Technology

With the help of blockchain technology, a safe and reliable education system can be built to ensure the credibility of promoting comprehensive quality evaluation. Blockchain is a technology combining cryptography, economics, and sociology. It is an innovative application mode of distributed data storage, point-to-point transmission, consensus mechanism, encryption algorithm, and other computer technologies in the Internet era. It has the characteristics of decentralization, tamperability, whole process trace, traceability, collective maintenance, openness, and transparency. Blockchain technology helps to build a safe and reliable education system, so as to strengthen intellectual property protection, effectively manage academic certificates, and drive accurate evaluation of education.

13.3.2.4 Educational Robot Accelerates Teaching and Learning Innovation

Educational robot is one of the representative products of artificial intelligence technology. With the help of educational robot, teachers can bear the teaching burden and accelerate the innovation of teaching and learning. Educational robots involve teaching robotics and educational service robots. Educational robot is the representative of the application of robot in the field of education. It is a typical application of artificial intelligence, speech recognition, and bionic technology in education. It aims to cultivate students' analytical ability, creative ability, and practical ability. Educational robot helps to accelerate the innovation of teaching and learning, so as to assist teaching and management and help the cultivation of students' core literacy.

13.3.2.5 Virtual Reality Technology Shapes Immersive Interactive Learning Experience

Virtual reality technology shapes immersive interactive learning experience. Virtual reality (VR) takes computer technology as the core and combines relevant science and technology to generate a digital environment that is highly similar to a certain range of real/imaginary environment in terms of vision, hearing, and touch. Users can interact and influence with objects in the digital environment with the help of necessary equipment, so as to produce their own feelings and experiences in the corresponding real environment. Virtual reality technology helps to shape the immersive interactive learning experience, so as to create a virtual teaching environment and promote the reform of teaching and learning methods.

13.3.2.6 Artificial Intelligence and Education Are Mutually Empowering

The application of AI will enhance the level of intelligence in economic and social development and effectively enhance public service and city management capabilities. The profound impact of AI on education is becoming a global consensus. In the future, we need to actively promote the deep integration of AI and education, and promote educational reform and innovation.

A new generation of artificial intelligence is booming all over the world and is profoundly changing people's way of production and life. At present, major countries in the world have accelerated the strategic layout of artificial intelligence, so as to accelerate the integration of artificial intelligence into school education. Artificial intelligence has been regarded as one of the main core technical forces to promote the progress of modern society. The development of artificial intelligence has been highly concerned by many experts and scholars, and many academicians have expressed their ardent expectations for the future development of artificial intelligence. Using artificial intelligence to solve the problem of educational reform and realize the mutual empowerment of artificial intelligence and education has attracted extensive attention and discussion all over the world. Sustainable development and a new round of scientific and technological revolution are driving educational reform. Under the background of education reform driven by the needs of sustainable development and a new round of scientific and technological revolution, the mutual empowerment of artificial intelligence and education has become an inevitable trend of the development of the times. Artificial intelligence and education are mutually empowered, and their deep integration will significantly improve educational productivity. The essence of educational artificial intelligence is the deep integration of artificial intelligence and the field of education, which makes learning, teaching, and management more intelligent, and makes future education truly have "wisdom".

AI has the characteristics of interdisciplinary, and AI and education show a trend of integration. Artificial intelligence includes weak artificial intelligence, strong artificial intelligence, and super artificial intelligence. At present, mankind has mastered weak artificial intelligence and is moving towards strong artificial intelligence. Education needs to face the future and cultivate innovative talents suitable for the intelligent era. Artificial intelligence technology can enable teachers to interact with students quickly in the classroom. Having AI knowledge will be everyone's basic accomplishment. The integration of artificial intelligence technology and school education has become a future trend, which provides technical guarantee for the realization of personalized learning and individualized learning and has become an important driving force for the development of education. The development of artificial intelligence technology has brought new opportunities for school education reform.

13.3.3 Planning and Design Process for Future Campus

Design thinking can serve as a methodology for planning and designing future schools, and the appropriate application of design thinking can help improve the design level of future schools. Referring to the five iterative stages of design thinking (empathize, define, ideate, prototype, and test), the planning and design of future schools can also be divided into five stages, as shown in Fig. 13.3.

- **Analyze and design the real needs of future campus**. Future campus design usually faces two situations: firstly, the upgrading and renovation of existing campuses, which usually requires consideration of compatibility with existing campuses; Additionally, the design of new campuses often faces greater design challenges. Fully investigating the practical needs of stakeholders such as learners, teachers, managers, and parents is crucial for designing future campus. In addition,

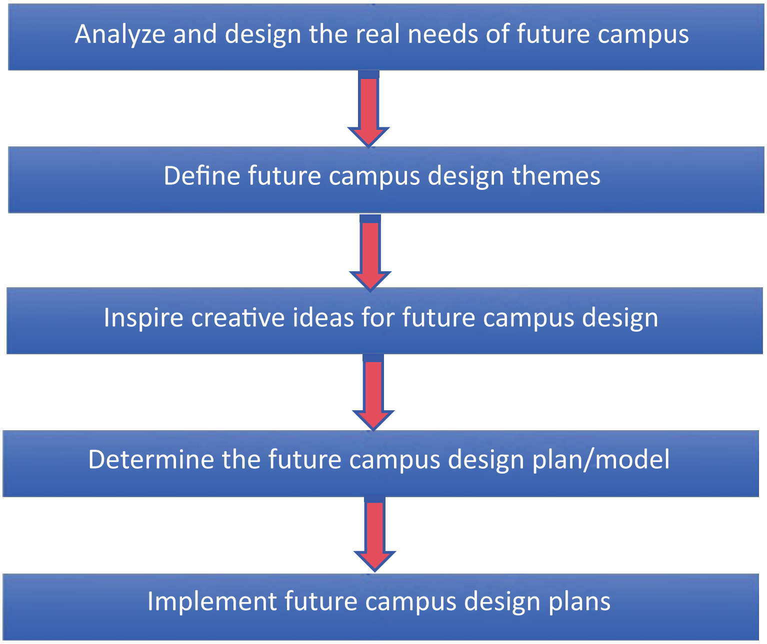

Fig. 13.3 Planning and design process for future campus

it is not only necessary to investigate current practical needs, but also to focus on future needs.

- **Define future campus design themes**. In this step, it is necessary to define the design theme of the future campus by combining the actual needs and future potential needs of stakeholders. That is to say, it is necessary to determine the characteristic direction of future school design, such as strengthening the environmental construction of future campuses, curriculum construction, student-centered, smart education services, knowledge creation, and other characteristic directions. In addition, it is also necessary to consider the concept of future education, such as the design of future learning and teaching environment, future curriculum design, future learning space, future learning center, and future talent cultivation. The specific content of future campus design is as follows: future campus (smart campus), OMO classroom, smart classroom, smart study (home smart learning environment), learning hub, smart dormitory, virtual teaching and research room, micro studio (short video + live streaming creation), virtual reality fusion venue, as well as artificial intelligence education experimental school, artificial intelligence laboratory, artificial intelligence technology experience hall, artificial intelligence classroom, intelligent training platform, intelligent training app, educational metaverse environment, etc.
- **Inspire creative ideas for future campus design**. To better design innovative and creative future campuses in the future, extensive research and practical cases

related to the latest future campus design are needed. By utilizing brainstorming and other methods, we extensively draw on existing design concepts and experiences to propose innovative ideas for future campus design. Finding inspiration for future campus design and generating innovative ideas is crucial.
- **Determine the future campus design plan/model**. It is necessary to use tools such as language and charts to depict future campus design plans, or use 3D software, holographic technology, virtual reality technology, etc. to create models of future campuses and create videos, animations, etc. of future campuses. The future campus design plan usually includes design background, design concept (creative source), design objectives, design features, construction tasks or projects, guarantee measures, implementation plans, expected effects, and other contents.
- **Implement future campus design plans**. It is usually necessary to implement several projects for future campus construction with sufficient funding support. During the project implementation process, it is necessary to consider future education concepts, future curriculum construction, future faculty construction, future innovative talent cultivation, and the comprehensive application of new media, new technologies, and new methods.

13.4 Discussion and Implications on Future Campus Design

13.4.1 The Development Trend of Future Campus

The future campus is a new type of intelligent learning environment designed for the needs of human future learning and teaching. The future campus will present the following development trends:

The future campus architecture will reflect the fourth-generation architectural concept, with a greater emphasis on creativity, environmental protection, green concepts, and ecological principles. Teaching buildings, office buildings, libraries, dormitories, and other buildings will pay more attention to creative design while meeting the basic functional requirements of learning, teaching, work, and life, in order to meet people's demands for aesthetics, comfort, creativity, and other aspects. Architectural design will further reflect the perfect combination of human and nature, allowing learners to experience the fresh charm of nature in a relaxed and enjoyable learning environment, activating innovative thinking and vitality.

The future campus will be deeply integrated with intelligent technology, reflecting the characteristics of intelligent interconnection, borderless, ubiquitous, and high-speed. In the future, people and people, people and things, and things and things on campus will achieve intelligent interconnection. In the future, the campus will break through the existing campus walls, deeply integrating internal and external, online and offline, virtual and reality. The future learning methods will be diverse and intelligent, enabling everyone to learn, constantly and everywhere. In the future, educational information on campus can achieve high-speed and effective dissemination, expand the channels of educational information dissemination, and optimize the effectiveness of educational information dissemination.

In short, the future campus should not only meet the basic needs of learning, teaching, and office work, but also be able to break the boundaries of the campus, effectively integrate virtual and real, meet the diverse needs of learners' aesthetics, creativity, and wisdom, promote the transformation from knowledge dissemination to knowledge creation, and from knowledge consumers to knowledge creators. The future campus will need to create a good environment and atmosphere for learners to create knowledge, posing a new challenge for future campus design.

13.4.2 Recommendations for Future Campus Design

Future campus design is very important for building a future campus. In order to create a comfortable, personalized, and intelligent learning environment for learners, it is necessary to pay attention to future campus design. From a conceptual perspective, future campuses need to focus on the concept of future education, face the practical demands of digital economy and smart society development, and cultivate innovative talents. Technically speaking, future campuses need to focus on the deep integration of intelligent technology with learning and teaching, providing intelligent learning services for students, teachers, and managers. From the perspective of user experience, future schools need to provide users with comfortable, personalized, and intelligent new learning spaces that can meet the diverse learning needs of learners, create an innovative culture and atmosphere, and promote the transformation from knowledge dissemination to knowledge innovation.

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Chapter 14
Design of Authentic Learning Based on Mixed Virtual Reality Learning Environment in K-12 Education

Su Cai and Jing Zhang

Abstract With the widespread application of new immersive media technologies, represented by Augmented Reality, in educational settings, the advantages of mixed virtual reality learning environment in addressing educational challenges and innovating teaching methods are increasingly prominent. The design of a mixed virtual reality learning environment has garnered significant attention from educators. Meanwhile, authentic learning, as a teaching approach that effectively promotes meaningful learning for students, is a topic of concern for many educators. This chapter analyzes the aforementioned two issues from the perspective of design thinking, supplemented by a series of case studies on authentic learning design in K-12 mixed virtual reality learning environment. Its aim is to assist educators in understanding the design principles and applicable scenarios of mixed virtual reality learning environment and guide students in engaging in authentic learning within this environment.

14.1 Introduction

Mixed virtual reality environment represents a confluence of virtual and real spaces, where the two coexist and intertwine. Unlike purely virtual or completely real environment, this environment enables users to perceive and interact with virtual objects while remaining immersed in their authentic physical surroundings. Augmented Reality (AR) technology serves as the primary technological foundation for creating mixed virtual reality environment. AR is a broader extension of Virtual Reality (VR), which refers to the technology that overlays virtual information onto the real world using computer techniques. It allows users to experience the integration of virtual content into their real environment through specific devices such as smartphones, tablets, AR glasses, or wearable headsets. Key features of AR technology include the integration of virtual and real elements, real-time interactivity,

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and three-dimensional perspectives (Azuma, 1997). In the realm of education, mixed virtual reality learning environments hold great promise. Constructing mixed virtual reality learning environment using AR technology offers several benefits: visualizing and concretizing abstract learning content, supporting context-based learning in ubiquitous environments, enhancing learner engagement, intuition, and focus, enabling natural interaction between learners and learning objects, and facilitating the integration of traditional and innovative learning approaches (Cai et al., 2016).

Authentic learning is an instructional approach that guides teaching and facilitates learning by emphasizing the integration of real-world experiences into the classroom. It involves engaging learners in authentic tasks and environments, where they actively participate in discussions, exploration, and collaboration to construct new knowledge and create real products (Chang & Huang, 2018). An essential characteristic and requirement of authentic learning is that students engage in inquiry of authentic tasks grounded in real-world contexts.

“Design” refers to the activity of solving complex human situations (Lawson, 2006), which exists in various aspects of daily life, including the field of education. Design thinking is an approach to solve problems from a user-oriented perspective. It involves understanding and addressing needs to generate solutions. Design thinking is particularly suited for addressing ill-defined or ill-structured problems (Buchanan, 1992). It provides support and guidance for individuals without a design background to innovatively address complex issues.

In recent years, with the introduction of immersive media technologies such as AR into authentic classrooms, there has been an increasing exploration of creating mixed virtual reality learning environment to enhance education and teaching. The advantages of mixed virtual reality learning environment in providing authentic learning experiences for students have gradually become apparent, leading to the recognition and acceptance of this blended learning approach. However, there is currently limited research summarizing the design principles of mixed virtual reality learning environment and providing guidance and references for authentic learning within this environment. It has become a pressing challenge for educators to fully leverage the unique advantages of mixed virtual reality learning environment to better support education and teaching, and to promote authentic learning for students. The creation of mixed virtual reality learning environment and the implementation of authentic learning within them involve a multitude of uncertain factors, representing a typical ill-structured problem. In such situations, considering the application of design thinking as an effective approach to address this challenge is worthwhile.

The rest of this chapter is organized as follows: Sect. 14.2 provides an overview of the current research status in the field of mixed virtual reality learning environment design based on AR technology. Section 14.3 introduces the design principles of mixed virtual reality learning environment. Section 14.4 presents five exemplary case studies of authentic learning design based on mixed virtual reality learning environment. Finally, Sect. 14.5 summarizes the content of this chapter and provides several recommendations for educators.

This chapter can help educators understand the design principles and applicable scenarios related to mixed virtual reality learning environment. Furthermore, the chapter extends its utility to educational technology developers, offering inspiration and reference for exploring ideas. Additionally, this chapter serves as a conduit for presenting to the public the efficacy of mixed virtual reality learning environment in enhancing student learning outcomes.

14.2 Related Work

Since Billinghurst and Kato (2002) pioneering use of AR technology in creating the Magic Book for educational purposes, researchers have conducted extensive explorations of combining AR technology with educational teaching and learning. Their aim has been to address educational challenges by enabling students to learn in mixed virtual reality learning environment. For example, Demitriadou et al. (2020) utilized the technological advantage of visualizing 3D objects through virtual and augmented reality to help students understand the distinction between two-dimensional and three-dimensional geometric shapes. This mixed virtual reality learning approach enhanced the interactivity of mathematics instruction and increased student interest, thereby facilitating more effective learning and comprehension of mathematical concepts. Weng et al. (2019) supplemented traditional science textbooks with mixed reality experiences, combining augmented and virtual reality, resulting in improved learning outcomes, particularly for students with limited spatial abilities. Cai et al. (2022) developed an AR education application that integrated multiple sensory channels to assist upper primary school students in learning acoustics. The results indicated that students who engaged in mixed virtual reality learning environment generally exhibited positive scientific learning attitudes and higher scientific cognitive beliefs. Programming language acquisition is critically important in science and technology education, but can be challenging for some students, especially beginners. In response, Teng et al. (2018) designed an AR learning system that provided visual representations and interactive experiences, enabling students to learn programming within mixed virtual reality learning environment. Ultimately, this approach enhanced students' learning efficiency and perception of system usability, workflow experiences, and overall user satisfaction. Cetin and Turkan (2022) enriched the science curriculum in remote education through mixed virtual reality learning environment. Specifically, they developed an AR-based application focusing on the "electric car" theme, which significantly improved students' academic performance and attitudes toward science courses. In the domain of physical education, which integrates theoretical knowledge with skill training, video-assisted instruction is commonly used. However, it lacks interactive exercises and fails to incorporate textbook learning and practical movement skills. To address this limitation, Chang et al. (2020) explored the use of AR in physical education by overlaying 3D models onto textbooks, creating a mixed virtual reality learning environment. The research findings demonstrated the superiority of AR-assisted instruction over video-assisted instruction, particularly in acquiring more challenging motor skills.

Authentic learning aims to provide students with real-life challenges to develop knowledge and skills through problem-solving in various contexts. It offers significant advantages in improving students' learning motivation, providing better learning opportunities, helping students prepare for a better future, making complex concepts easier to understand, and promoting the combination of theory and learning (Chang & Huang, 2018). Authentic learning requires students to be immersed in real learning environments, and emerging information technologies have been employed to create authentic teaching settings, including immersive media technologies such as AR. For instance, Chang et al. (2010) utilized mixed reality technology and robotics to design the RoboStage system, which incorporated real-life scenarios, significantly improving the authenticity of learning tasks and positively influencing student motivation. Cochrane et al. (2018) employed mobile virtual reality (mVR) to create an authentic learning environment for health education, allowing students to experience immersive simulations similar to real healthcare team scenarios. Chin and Wang (2021) proposed an augmented reality (AR)-based mobile tourism system for authentic learning activities, enabling students to observe and learn critical information about cultural heritage. The AR-based mobile roaming system demonstrated the potential to significantly enhance students' learning outcomes in terms of memory retention while also improving their interest in learning and performance in outdoor environments.

The concept of design thinking originated from the Nobel laureate Herbert Alexander Simon, who viewed it as a general problem-solving process (Simon, 1969). It was formally introduced by Peter Rowe, a professor at the Harvard Graduate School of Design, in his book "Design Thinking" published in 1987 (Rowe, 1987). Today, design thinking has gained widespread adoption across various industries and disciplines. Tim Brown, the CEO of IDEO, a renowned creative design company, believes that design thinking embodies a user-oriented approach to design, considering the needs and behaviors of users, as well as the feasibility in terms of technology and business (Brown, 2008). Design thinking involves applying inductive reasoning to continuously shift perspectives between the desired goals or functions and the viable forms that can achieve those goals (Cross, 2011). Designers face the challenge of dealing with complex design objects, services, or systems and making them work cohesively. They need to address the questions of "what is the requirement" and "how to realize the requirement", and then test their solutions by integrating these considerations (Dorst, 2011). It is important to recognize that no single design solution can effectively address all future design contexts. Therefore, designers must possess the ability to discern design solutions and systematically create and refine the design process based on guiding principles. Stanford University's D SCHOOL design thinking model, encompassing Empathy, Define, Ideate, Prototype, and Test (EDIPT), is a well-established and influential framework in the field (Deitte & Omary, 2019; She et al., 2022). Similarly, IDEO's 3I model of design thinking—Inspiration, Ideation, and Implementation—is also a classic framework in the realm of design thinking (Brown, 2008).

Design thinking provides educators with a framework and reference to address the challenging instructional design problems they face. Henriksen et al. (2020)

conducted a study on a graduate teacher education course at a university in the Midwest United States, where the Stanford design thinking model was employed. The study found that exposure to and practice of the design thinking process enabled educators to creatively solve practical problems relevant to their backgrounds. Deitte and Omary (2019) explored innovative solutions in medical education by employing the design thinking process to better understand the experiences of medical students and design educational activities that inspire their learning, optimizing learners' educational experiences. She et al. (2022) utilized design thinking to design and develop the fully online course #OpenTeach, integrating the five iterative stages of design thinking into the design and development of course materials. The results demonstrated that instructional designers could employ the design thinking process to achieve empathy with learners, ensuring their active engagement and the achievement of course learning objectives. Skywark et al. (2022) created a new interdisciplinary graduate course called "Design Thinking for the Public Good" using the design thinking process, resulting in key insights that can be applied in course design work. Traifeh et al. (2019) followed the Stanford University design thinking model to assess the functionality of MOOC collaboration spaces, implementing prototype design and testing iterations, ultimately improving the digital MOOC space and enhancing learner engagement.

Although there is extensive research on utilizing design thinking to assist in instructional and curriculum design, there is a scarcity of exploration from a design thinking perspective on how to design mixed virtual reality learning environment in K-12 education and how to design authentic learning within this environment.

This chapter attempts to answer three research questions:

What principles should be followed when designing mixed virtual reality learning environment in K-12 education?

How can authentic learning be conducted within the context of mixed virtual reality learning environment?

Is authentic learning within mixed virtual reality learning environment effective?

14.3 Design Principles

The AR technology serves as the principal technological means to actualize the mixed virtual reality learning environment. Based on the main idea of design thinking and the technological characteristics of AR, and informed by our practical experience, we propose a set of guiding principles for designing mixed virtual reality learning environment utilizing AR technology in K-12 education.

14.3.1 User-Oriented and Student-Centered

Design thinking revolves around the users' needs, focusing on both their current and potential future needs, and gaining deep insights and understanding. When designing, it is essential to start with the actual needs of students and think from their perspective to address obstacles in their learning process. Educators need to first identify pain points and challenges in K-12 education and then consider whether AR technology can provide solutions. For instance, certain science experiments in K-12 education are constrained by high costs, practical limitations, or hazardous elements, making it difficult to conduct them in traditional classrooms. As a result, students miss out on hands-on experimentation opportunities. While this may be challenging to address under real-world conditions, it remains a genuine need for students. In such cases, the introduction of AR technology and the creation of a mixed virtual reality learning environment can overcome these difficulties.

14.3.2 Coordinating Multiple Elements to Generate Synergy

When designing, it is important to consider multiple elements and seek a synergistic effect among them. This includes identifying complementary teaching models and strategies that align with the mixed virtual reality learning environment, and, if necessary, adapting existing models or developing new ones. In addition to considering teaching models and strategies, educators, learners, and other intermediaries that connect them, as well as environmental factors, should all be taken into account. Educators need to find the optimal solution for designing mixed virtual reality learning environment and activities by considering how these elements interact and support each other. For example, in some mixed virtual reality environment, collaborative inquiry activities require students to work in small groups. Educators should consider factors such as the choice of inquiry models, the appropriate group size, and the allocation of roles within the group.

14.3.3 Iterative Optimization and Reflection

Design thinking demands that designers continuously contemplate the interplay between desired objectives or functionalities and the appropriate forms to achieve them. When engaging in the design process, it is crucial not to hastily settle on a design solution. Instead, one should explore diverse possibilities through divergent thinking, discern the optimal choice for the present circumstances, and then proceed with testing, validating, and improving through iterative cycles of implementation. Throughout this process, educators should prioritize self-reflection. Each self-reflection offers an opportunity to reexamine the design solutions and their effects, fostering a deeper comprehension of how these designs facilitate or impede the attainment of the ultimate goals. Engaging in reflective practice before implementing the design helps educators mitigate the costs and risks associated with making adjustments during the teaching process.

14.3.4 Focus on Interaction and Feedback, not just Demonstrations

In mixed virtual reality environment, information can be presented in 3D form, which offers significant advantages in providing learners with immersive experiences. However, there is a risk of excessive focus on the presentation and demonstration capabilities, while neglecting the interactive potential of this environment. It is common for educators to design mixed virtual reality learning environment that primarily showcase and present virtual objects, emphasizing the demonstration aspect without paying sufficient attention to the interaction between students and virtual learning objects. In reality, mixed virtual reality learning environment enable learners to interact with virtual objects in a natural manner. This interaction is highly beneficial as it increases learner engagement and ensures their active participation in learning activities.

14.3.5 Be Specific and Appropriate

AR technology should not be used indiscriminately in K-12 education, avoiding the risk of “show-off” teaching. The purpose of designing mixed virtual reality learning environment is to address educational challenges that cannot be effectively resolved using traditional approaches, with the ultimate goal of genuinely supporting both teachers and students in their teaching and learning processes. It is essential to maintain this fundamental principle throughout the design process, ensuring that the focus remains on enhancing actual teaching and learning outcomes. When incorporating AR technology in authentic classroom settings, it is crucial to adhere to the principle of practicality, utilizing AR technology based on genuine educational needs. By creating purposeful mixed virtual reality learning environment, educators can effectively tackle instructional challenges that are difficult to address in the real world, and when necessary, synergistically integrate other supplementary technologies to further enhance the learning experience.

14.4 Case Studies

This section showcases five typical case studies of authentic learning in K-12 education using mixed virtual reality learning environment. The cases include high school physics instruction on the photoelectric effect, middle school biology exploration of microscopic cells, middle school mathematics learning on probability, middle school mathematics visualization of electromagnetic fields, and primary school science inquiry integrating EIA (Exploration, Investigation, Application) inquiry model. These cases were designed based on the five principles discussed in Sect. 14.3, addressing learners' needs identified through preliminary research. The design process involved comprehensive consideration of various factors and underwent iterative refinement and optimization with team members' input. Emphasis was placed on promoting learner interaction. These case studies demonstrated favorable educational outcomes in practice. The design of authentic learning activities drew on and integrated the 3I model of design thinking.

14.4.1 High School Physics Teaching Case: Photoelectric Effect

The study of the photoelectric effect in the optics section of high school physics presents challenges such as high learning difficulty, complex and abstract concepts, which often lead to students struggling with this topic. Consequently, students' self-efficacy in physics learning and their understanding of physics concepts may be compromised to some extent. To address this issue, we have designed and developed an augmented reality (AR) application specifically for high school students to learn about the photoelectric effect in optics. This AR application creates a mixed virtual reality learning environment, aiming to provide an effective solution to this challenge (Cai et al., 2021).

14.4.1.1 Mixed Virtual Reality Learning Environment Design

With the assistance of the "Photoelectric Effect" AR teaching application, learners can explore the conditions for the occurrence of the photoelectric effect and observe the motion state of emitted electrons under positive and negative voltages. As shown in Fig. 14.1, by placing the designated recognition card within the camera's field of view, learners can directly manipulate the experimental parameters such as light intensity, light frequency, resistance, and voltage by covering the buttons on the recognition card or clicking the buttons on the tablet screen. They can observe the resulting experimental phenomena in the blended space of reality and virtuality and then summarize the experimental laws.

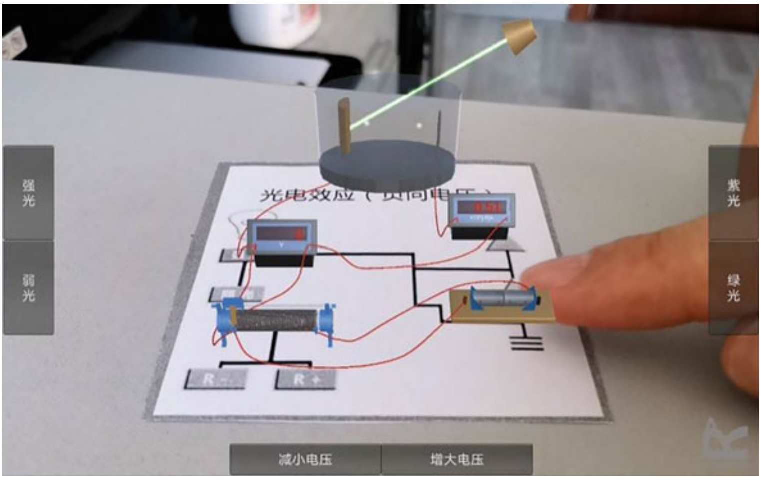

Fig. 14.1 Photoelectric effect AR teaching application

14.4.1.2 Authentic Learning Activity Design

Students from Helong Middle School, Hubei Province in China collaborated in groups and utilized AR technology to simulate the photoelectric effect experiment, as shown in Fig. 14.2. They went through the process of "posing questions—making hypotheses—conducting experimental verification—engaging in discussion and communication". This process enhanced their observational skills, teamwork awareness, and ability to apply knowledge comprehensively to problem-solving, while acquiring scientific inquiry methods. The stage of "posing questions" corresponded to the "Inspiration" phase in the 3I model. During this stage, students clarified the research questions, had a clear understanding of the purpose of the inquiry activity, and generated preliminary ideas. They were curious about the conditions and influencing factors of the photoelectric effect. The stage of "making hypotheses" corresponded to the "Ideation" phase in the 3I model. Students formulated their own hypotheses and attempted to develop a plan for investigating the photoelectric effect experiment. Group members contributed to and refined the plan through discussions. The stage of "conducting experimental verification" corresponded to the "Implementation" phase in the 3I model. During this stage, students followed the established plan to carry out the experimental inquiry activity, implemented the experimental plan, and obtained experimental results regarding the conditions and influencing factors of the photoelectric effect. Finally, students summarized the experimental results, as well as their insights and experiences gained during the experimental process, through discussion and communication.

Fig. 14.2 Record of photoelectric effect learning activities

14.4.1.3 Experimental Verification of Teaching Effect

A controlled experiment was conducted to evaluate the effectiveness of students' physics learning on photoelectric effects in a mixed virtual reality learning environment. The participants consisted of 98 high school students aged between 16 and 18, who were randomly assigned to an experimental group (49 students) and a control group (49 students). After a 5-week instructional intervention, quantitative data collection tools were employed to gather experimental data.

The data analysis results revealed that the mixed virtual reality physics learning environment: (1) significantly enhanced students' self-efficacy in physics learning in terms of conceptual understanding, higher-order cognitive skills, practice and communication; (2) guided students toward a preference for higher-order physics learning concepts rather than lower-order concepts; (3) stimulated students' deep-level intrinsic motivation for learning.

One lesson from this study is that mixed virtual reality learning environment should pay attention to inquiry process rather than presentation. The ability of AR in adjusting parameters and observing phenomena in real-time should be taken into more virtual experiments crated by AR. Furthermore, the stability of software interactions can also exert a certain degree of influence on students' learning experiences.

14.4.2 Junior High School Biology Teaching Case: Exploring Microscopic Cells

The study of cells is crucial in middle school biology education. However, the small and intricate nature of cell structures makes it challenging to observe them clearly using optical microscopes. Additionally, conducting experiments to investigate factors affecting processes like photosynthesis and respiration is often limited in regular classroom settings due to objective constraints. To address these issues, we have designed and developed an AR application specifically for middle school biology students. This AR application creates a mixed virtual reality learning environment, providing a solution for students to explore the microscopic world of cells and overcome the limitations of traditional methods.

14.4.2.1 Mixed Virtual Reality Learning Environment Design

The case utilized three AR teaching applications, namely “Cell Structure”, “Respiration”, and “Photosynthesis”, to create a mixed virtual reality learning environment for students.

With the support of the “Cell Structure” software, students can observe virtual models of cell structures on their device screens. They can interact with the models by using their fingers to zoom in, rotate the models, or hold recognition cards on the table to observe the current morphology of the cell structure from a 360-degree perspective. After completing the observation, clicking the “Function” button in the top-left corner reveals the corresponding functions of the cell structure. To hide the text, students can click the “Back” button.

In the “Photosynthesis” software, students can explore the factors influencing photosynthesis through a virtual experimental model. The top left corner displays three factors: light intensity, temperature, and carbon dioxide concentration, along with corresponding sliders. When the corresponding recognition card is recognized, the values are displayed, and multiple yellow spherical substances (representing produced organic matter) and bubbles (representing oxygen generated through photosynthesis) appear inside the chloroplast model. By adjusting the sliders from 1 to 6 for the three factors, students can observe changes in bubble size and the amount of yellow spherical substances, as well as the alteration of the oxygen value in the top right corner.

The functionality of the “Respiration” software is similar to that of the “Photosynthesis” software. It allows students to explore the effects of water content, temperature, and oxygen concentration on cellular respiration through a virtual experimental model, as shown in Fig. 14.3.

14.4.2.2 Authentic Learning Activity Design

Using the exploration of photosynthesis as an example, a class from Shuixiu Middle School, Taigu County, Shanxi Province in China was divided into groups of four students each, with two tablets assigned to each group. Within each group, students engaged in discussions to reach a consensus and determine a research topic of interest related to the effects of temperature, carbon dioxide, or light intensity on the rate of photosynthesis. This corresponded to the “Inspiration” stage in the 3I model. Once the topic was determined, each group participated in group discussions to brainstorm ideas and refine their experimental investigation plans. They explored the chosen factor’s impact on the rate of photosynthesis and made improvements to their experimental plans. This corresponded to the “Ideation” stage in the 3I model. Using

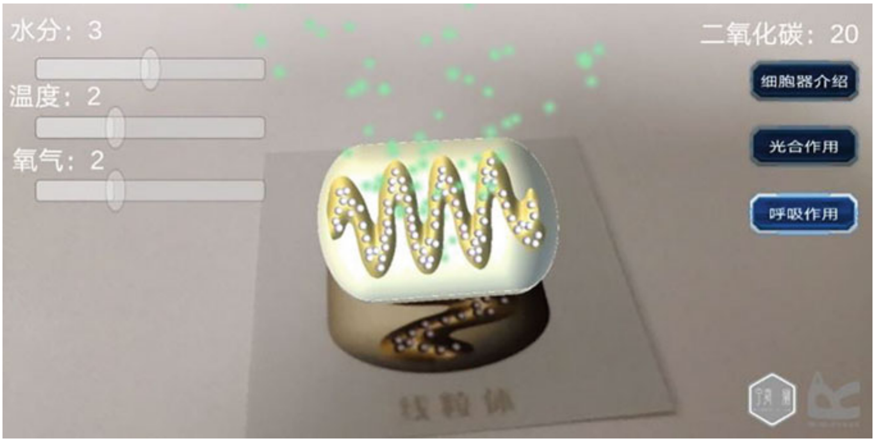

Fig. 14.3 Exploring microscopic cell teaching application

the "Photosynthesis" AR teaching application, each group conducted the experiment and drew conclusions based on their findings. This corresponded to the "Implementation" stage in the 3I model, as shown in Fig. 14.4. After completing the experiments, each group recommended a representative to present their experimental plan using a multimedia digital display platform. The process of operating the AR application was demonstrated through projection. The teacher analyzed and evaluated the students' thoughts and guided them in reflecting on and improving their experimental designs and results.

Fig. 14.4 Record of exploring microscopic cell learning activities

14.4.2.3 Experimental Verification of Teaching Effect

A controlled experiment was conducted to verify the effects of students' learning of biological cell knowledge in a mixed virtual reality learning environment. The study included 100 seventh-grade students from a certain middle school, divided into an experimental class (Class A) and a control class (Class B), with 50 students in each class. The experimental class utilized AR teaching application for learning, while the control class engaged in learning through analyzing materials and group discussions. Before the start of the course, students from both Class A and Class B completed the "Attitude towards Biology Learning Questionnaire" and the "Inquiry Topic Questionnaire" to control for any existing differences between the two classes. At the end of the course, students from both classes completed a post-test questionnaire to examine whether there were significant differences in students' attitudes toward biology learning and their grasp of biological knowledge under the two different conditions. Interviews were also conducted with student representatives and school teachers.

The results of the experiment demonstrated that, both in terms of knowledge mastery and learning attitudes, students in the mixed virtual reality biology learning environment with the involvement of AR technology exhibited more ideal performance. When students had the opportunity to personally engage in hands-on operations, observe experimental variations with their own eyes, and actively explore to obtain experimental results, their grasp of knowledge became more solid and clear. Moreover, their enthusiasm for biology learning was effectively stimulated.

14.4.3 Junior High School Mathematics Teaching Case: Probability Learning

The knowledge of probability in mathematics is closely related to everyday life, but it can be abstract and difficult to comprehend, resulting in a cognitive load for students. To address this challenge, we develop an AR educational game application for guiding middle school students in learning probability concepts. This AR application utilizes augmented reality technology to create a mixed virtual reality learning environment, aiming to provide students with an immersive and intuitive learning experience, thereby addressing the difficulties associated with abstract probability concepts (Cai et al., 2019, 2020).

14.4.3.1 Mixed Virtual Reality Learning Environment Design

This case utilized three AR educational gaming applications, namely "Seven", "Super Space", and "Magic Coins" to create a mixed virtual reality learning environment for students, as shown in Fig. 14.5. Taking the "Magic Coins" AR educational application

(a) Seven (b) Super Space (c) Magic Coins

Fig. 14.5 Probabilistic learning AR teaching application

as an example, students can toss a virtual coin in a real environment. Before starting the game, two parameters need to be set: interval time and recognition time. The interval time refers to the minimum time interval between the camera's recognition of two coins, while the recognition time is the minimum duration for the camera to successfully recognize a coin. Once the game is launched, the mobile device's camera can capture and identify the heads or tails of the coin in the captured image and display the corresponding 3D model on the screen to indicate a successful recognition. Upon successful recognition, the system automatically counts the current state of the coin and updates the number and frequency of heads and tails that have been recognized. The top-left corner of the system records the number of heads and tails, while the bottom-right corner displays a line graph that dynamically updates the frequency of heads. When students exit the game, the historical data of the game will be saved in the database.

14.4.3.2 Authentic Learning Activity Design

Taking the coin tossing activity as an example, as shown in Fig. 14.6, students from the Branch School of Beijing No. 50 Middle School in China worked in pairs to conduct experimental investigations. Firstly, students needed to clarify the purpose of the experiment and familiarize themselves with the functionalities of the AR educational gaming application, which corresponded to the "Inspiration" stage of the 3I model. Then, based on the experiment's purpose and the functionalities provided by the AR educational application, they developed an experimental plan and divided the tasks. One person was responsible for tossing the coin, while the other was responsible for recognizing the outcome. This corresponded to the "Ideation" stage of the 3I model. Finally, using the "Magic Coins" AR educational gaming application, they repeated the experiment multiple times to determine the probability of obtaining heads in the coin toss. This corresponded to the "Implementation" stage of the 3I model. In this case, the purpose of creating a mixed virtual reality learning environment was not just for demonstration but primarily for interaction and exploration.

Fig. 14.6 Record of probabilistic learning activities

14.4.3.3 Experimental Verification of Teaching Effect

A study was conducted to verify the effectiveness of students' learning of mathematical probability knowledge in a mixed virtual reality learning environment through a controlled experiment. The study selected 59 first-year junior high school students from a certain middle school, with 31 students in the experimental group and 28 students in the control group. A total of 59 questionnaires were collected, and based on the completeness of the responses, 25 valid questionnaires were obtained for both the experimental and control groups.

The study assessed the impact of learning in the mixed virtual reality learning environment on students' learning outcomes in the probability chapter through pre-tests and post-tests. The pre-test and post-test both covered questions related to probability and life experiences, probability theory, and the relationship between the two aspects. In addition, the post-test included some open-ended questions to gather students' experiences while using the AR learning tool. The study found that in the pre-test, the average scores of the experimental group were lower than those of the control group in the aspect of probability and life experiences. However, in the post-test, the experimental group scored higher on average in this aspect compared to the control group. Similarly, in the aspect of connecting life experiences with probability theory, the performance of the experimental group was somewhat better than that of the control group. Although the study did not confirm statistically significant findings in quantitative data, qualitative responses from the open-ended questions indicated that mathematics teaching in the mixed virtual reality space can significantly improve students' learning motivation.

14.4.4 Junior High School Physics Teaching Case: Visualization of Magnetic Fields

The physics discipline encompasses numerous abstract concepts, such as magnetic fields. Magnetic fields are invisible and intangible under existing conditions, making it challenging for learners to grasp the concept accurately and intuitively through two-dimensional teaching resources like images and videos. To address this issue, we have designed and developed a magnetic field visualization application based on AR technology and somatosensory natural interaction technology. This application creates a mixed virtual reality learning environment for students (Cai et al., 2017). It not only leverages the demonstrative advantages of AR technology but also incorporates the characteristics of somatosensory natural interaction technology, resulting in a highly effective tool for classroom instruction.

14.4.4.1 Mixed Virtual Reality Learning Environment Design

Using AR technology to visualize magnetic fields and utilizing Microsoft's Kinect as an interactive device, the program applies the Biot-Savart law to calculate the magnetic field strength and direction at each point, students only need to connect the Kinect sensor to the computer. With the camera on the Kinect, as shown in Fig. 14.7, they can manipulate the movement of a magnet by moving their hands in the experimental interface of the program. They can observe the real-time changes in the distribution of the magnetic field and the deflection of small magnets within the magnetic field. Through this interaction, students can investigate the distribution of magnetic field lines under different conditions and summarize the laws.

Fig. 14.7 Visualized magnetic field AR teaching application

Fig. 14.8 Record of visualized magnetic field learning activities

14.4.4.2 Authentic Learning Activity Design

In groups of four, students at Capital Normal University High School in China conducted collaborative inquiry learning within a mixed virtual reality learning environment to explore and acquire knowledge related to magnetic fields and field lines, as shown in Fig. 14.8. The students first clarified the research question and experimental objectives and gained initial experience with the AR teaching application for electromagnetic fields. This process corresponded to the stage of “Inspiration” in the 3I model. Building upon this, the students engaged in group discussions to develop an experimental plan and allocate responsibilities, ensuring the scientific validity and feasibility of the plan. This corresponded to the stage of “Ideation” in the 3I model. Finally, based on the predetermined plan and assigned roles, the students carried out the experimental investigation, recording both the process and the resulting data. This corresponded to the stage of “Implementation” in the 3I model. To ensure the participation and quality of collaboration within each group, specific task roles were assigned to each student, such as commander, operator, recorder, or presenter. The commander guided the operator in operating the equipment and coordinated task allocation. The recorder completed the investigation report and recorded the findings and conclusions on the report sheet as required. After the experiment, the presenter reported the process and results to the whole class, either through voluntary presentations by group members or selected presentations by the teacher. These role designs aimed to stimulate students’ active engagement in hands-on experimentation, critical thinking, content assimilation, collaboration, and teamwork. At the conclusion of the experiment, the teacher summarized the learning objectives and the experiment process, ensuring that each student established accurate concepts based on the group’s collective findings.

14.4.4.3 Experimental Verification of Teaching Effect

A controlled experiment was conducted to examine the effects of mixed virtual reality learning environment on students’ learning of physics electromagnetic field concepts. The participants consisted of 42 eighth-grade students who were randomly assigned to two groups: Group A (control group without AR technology) and Group B (experimental group using AR technology).

During the study, three assessments on magnetic field knowledge were conducted: pre-test, mid-test after classroom exploratory activities, and post-test half a month after the experiment. A questionnaire survey was administered to the students in the experimental group to gather their attitudes toward the AR teaching application. In addition, interviews were conducted with frontline physics teachers from the experimental school to collect their insights and opinions. The results indicated that the use of AR-based motion-sensing teaching software facilitated students' understanding of abstract concepts such as magnetic fields and magnetic field lines, leading to more efficient learning of physics principles. The mixed virtual reality learning environment not only significantly improved academic performance but also had positive effects on enhancing students' interest in learning.

However, it is worth noting that it is not prominent in helping students move from learning objectives to laws. If we do not provide the proper guidance, the final teaching evaluation results will be affected by students' unfamiliarity with the equipment and the environment. They also reported that the not-so-friendly user interface negatively affected their learning experience.

14.4.5 Primary School Science Teaching Case: Inquiry Activities Combined with EIA Inquiry Model

During the process of scientific learning, mixed virtual reality learning environment can effectively enhance students' overall scientific literacy in terms of observation, inquiry, analysis, and more. Previously, in order to facilitate effective guidance in elementary science education, researchers have proposed various teaching and learning models, each with its own focus and advantages. However, seamlessly adapting these models to elementary science education based on mixed virtual reality learning environment can be challenging. To address this issue, we have redeveloped the EIA (Exploration, Investigation, Application) inquiry model, which supports teachers in conducting experiments that are difficult to implement in the real world within mixed virtual reality learning environment. By integrating existing theories with contemporary contexts, we aim to enhance students' scientific literacy while reducing their cognitive load (Yang et al., 2021).

14.4.5.1 Mixed Virtual Reality Learning Environment Design

This case corresponds to the teaching content of "Earth's rotation and revolution" in science. It utilizes three AR teaching applications: "Secrets of Stars", "Secrets of Seasons", and "Secrets of Shadows", to create a mixed virtual reality learning environment for students.

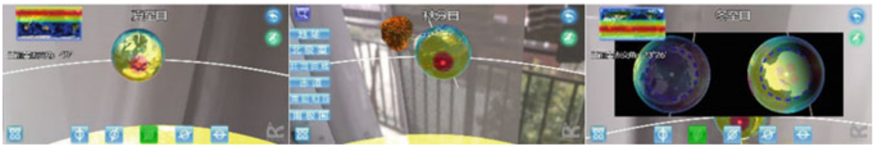

Fig. 14.9 Secret of seasons AR teaching application

Taking "Secrets of Seasons" as an example, as shown in Fig. 14.9, students can open the application and see virtual objects such as the Sun, Earth, and their orbits in the real environment. There is a tree on the Earth, and the Earth exhibits a color gradient from the equator to the poles, representing the distribution of heat transmitted by the Sun. By clicking on the Earth, it can be set in motion for revolution. The color of the tree and the position of the direct sunlight change, depicting the variations of the four seasons. The "Menu" button in the lower left corner allows students to control the display of the equator, Tropics of Cancer and Capricorn, Arctic Circle, and Antarctic Circle. Moving to the next scene, by clicking the "Menu" button in the lower left corner, students can change the tilt angle of the Earth's axis in the virtual space. The degree of the axial tilt, represented by the text below the map in the upper left corner, shows the obliquity of the ecliptic. The color band representing heat distribution on the map moves as the Earth revolves. Clicking on the Earth triggers its revolution, and the position of the direct sunlight moves accordingly. By clicking the "Satellite" button, students can observe the phenomena at the North and South Poles and explore the changes in polar day and night caused by variations in the Earth's axial tilt.

14.4.5.2 Authentic Learning Activity Design

The activity followed the EIA inquiry model, which consisted of three stages: Experience, Inquiry, and Application. These stages aligned with the Inspiration, Ideation, and Implementation processes of the 3I model. Each stage had corresponding AR functionalities, teacher activities, and student activities. Student activities included learning activities and inquiry activities. Evidence gathering, information processing, communication, and presentation were common activities for students across all stages. The EIA inquiry model considered these three activities as intermediaries for learning activities and other inquiry activities in each stage. The model also included: (a) posing questions and forming hypotheses; (b) creating models and drawing conclusions; (c) conclusions and reflections as learning objectives in each phase. In student activities, the arrows represented various pathways for students to achieve inquiry goals and maintain the learning cycle, with their ideas inspired by the 5E model, as shown in Fig. 14.10.

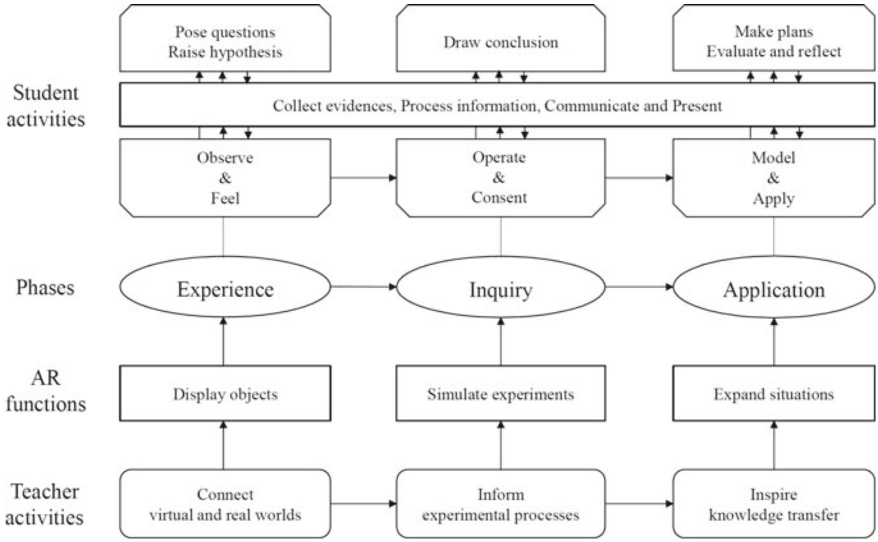

Fig. 14.10 EIA inquiry model

14.4.5.3 Experimental Verification of Teaching Effect

A mixed-methods approach was utilized to examine the impact of teaching following the EIA inquiry model in a mixed virtual reality learning environment on students' scientific inquiry activities. The study involved 209 fifth-grade students (aged 10 or 11) from three parallel classes in Funan No. 1 Primary School, Anhui Province in China. Each parallel class consisted of approximately 70 students, which is a common class size in most public schools in the region. These students received two weeks of science instruction on the topic of "Earth's Rotation and Revolution" for three hours per week, taught by the same science teacher. In the first class, students learned in a mixed virtual reality learning environment following the EIA inquiry model, as depicted in Fig. 14.11. Each lesson comprised three stages: Experience, Inquiry, and Application, with the involvement of augmented reality (AR) technology in each stage. In the second class, students learned in a mixed virtual reality learning environment combined with the inquiry model. Each lesson consisted of five steps: (1) situational contextualization, (2) inspirational thinking, (3) independent investigation, (4) cooperation and communication, (5) summarization and improvement. AR technology was used in the first and third steps. In the third class, students learned in a conventional media environment combined with the EIA inquiry model, following the same sequence as the second class.

A survey method was employed to assess the differences in academic performance, scientific literacy, and cognitive load among students from three classes who engaged in learning activities in different environments. The experimental results were further interpreted through interviews conducted with students and

Fig. 14.11 Record of AR environment combined with EIA inquiry model learning activities

local school teachers. The findings demonstrated that both the EIA inquiry model and mixed virtual reality learning environments significantly improved students' academic performance. Additionally, the EIA inquiry model exhibited strong adaptability to mixed virtual reality learning environment, and the combination of the two effectively enhanced students' scientific literacy while reducing cognitive load.

One lesson from this study is that if students do not possess a head-start advantage in terms of scientific literacy, learning within a mixed virtual reality learning environment under such circumstances may lead to an increase in cognitive load, resulting in underperformance in learning activities and scientific literacy.

14.5 Summary and Suggestions

The aforementioned cases demonstrate that mixed virtual reality learning environment and authentic learning activities designed based on design thinking can effectively meet the established instructional needs and enhance learners' learning outcomes to a certain extent. The application of mixed virtual reality learning environment in K-12 education is extensive, encompassing natural sciences, humanities, and art disciplines. Such environment can create immersive contexts, provide experimental support, and facilitate skill development. It offers an effective approach to addressing educational challenges in real-world settings. If educators can harness this environment effectively, it can bring forth new possibilities in education and instruction. Novice designers can refer to a typical design thinking model and incorporate the five principles discussed in Sect. 14.3 to design the required mixed virtual reality learning environment and authentic learning activities. Through an iterative process of "design-action-reflection" that combines theory and practice, they can develop authentic learning designs that align with practical needs in mixed virtual reality learning environment.

There are some suggestions for novice designers. (1) Listen to students: Pay close attention to the voices of students as the key stakeholders in education. Enhance your insights and judgment regarding student needs by actively seeking their opinions and feedback. (2) Collaborate with fellow teachers: Engage in discussions and brainstorming sessions with colleagues to explore various design ideas using design thinking methods. Benefit from collective wisdom and diverse perspectives. (3) Emphasize reflection and accumulate experience: Reflect on your design process and accumulate experience. Learn from existing exemplary cases by observing and studying them, extracting useful references. (4) Balance technology and instructional strategies: Avoid solely focusing on the use of AR technology. Pay equal attention to instructional strategies and teaching methods. In practice, the ideal construction of mixed virtual reality learning environment often requires the integration of AR technology with instructional design. (5) Beware of technological determinism: Teachers should not delegate all teaching tasks to technology. Technology should serve as a supportive tool, and teachers should actively assume a leading role while ensuring student-centered. (6) Teach students the spirit and methods of design thinking: Guide and encourage students to apply design thinking in designing and conducting inquiry-based activities, fostering their active engagement and exploration.

Finally, there are several key takeaways that deserve consideration: (1) The stability of interactions and the design of interfaces within the mixed virtual reality learning environment are of paramount importance, as they can significantly impact students' learning experiences. (2) Learning within a mixed virtual reality learning environment requires thoughtful guidance and a certain level of foundational knowledge; otherwise, optimal learning outcomes might not be achievable. (3) While the mixed virtual reality learning environment could potentially enhance student learning outcomes in specific dimensions, this does not necessarily imply uniform effectiveness across all aspects. These recommendations aim to support novice designers in creating effective mixed virtual reality learning environment and promoting meaningful learning experiences for students.

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Chapter 15
The Theory and Practice of Home-School-Community Collaborative Education in the Era of Artificial Intelligence

Liang Yu, Haiyan Zhou, Jiayi Shao, and Djatmiko

Abstract This study examines the current state of collaborative education among homes, schools, and communities while drawing on the theories of overlapping domains of influence and synergy. The research firstly investigates the interrelationship between family, school, and community and proposes the home-school-community collaborative education model in the era of artificial intelligence, encompassing elements such as subject, space, resources, data, and technology. The study further reveals that the collaborative education form of home, school, and community is composed of education goal, education environment, education subject, education process, education resources, and education evaluation. Lastly, the study proposes the practical path of home-school-community collaborative education and emphasizes the importance of fostering a strong collaborative relationship among homes, schools, and community.

15.1 Introduction

In the 1980s, Epstein put forward the hypothesis of Overlapping Spheres of Influence, on the basis of which he found that the integrated model of home-school-community cooperation could help to improve students' learning efficiency (Epstein, 1990). In this regard, the U.S., the U.K., and Japan have conducted a great deal of research on home-school-community collaboration and accumulated rich practical experience. However, studies on home-school-community co-education in K-12 education have pointed out that there are deviations in the positioning of the functions of the main bodies of home-school-community, and that the contents and forms of cooperation are monotonous and lack the effectiveness of collaborative education. Consequently, prioritizing a new collaborative education paradigm that seamlessly integrates the home, school, and community becomes a crucial step in cultivating an

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optimal educational environment and promoting educational modernization. Technological empowerment offers a promising avenue for transforming the home-school-community collaborative teaching model. In recent years, artificial intelligence (AI) technology has revolutionized differentiated teaching, enhanced instructional methods, and facilitated collaborative learning (Huang et al., 2021). AI holds a natural advantage in empowering educational institutions, strengthening home-school connections, and creating ubiquitous learning environments. The reform of collaborative education within the home, school, and community is imminent. In light of these technological advancements, it is crucial to contemplate how we can reshape the collaborative education mode and enhance its effectiveness.

15.2 Literature Review

15.2.1 Collaborative Parenting to Collaborative Education by Home, School, and Community

The study about home-school-community collaborative education first began in the U.S. Since the enactment of the No Child Left Behind Act by the Bush administration, the U.S. has raised the responsibility of elementary and secondary schools to promote student academic achievement to the national level (Heckman, 2008). In 2014, the U.S. Department of Education released the Dual Competency Framework, which is designed to enhance collaboration between elementary and secondary schools and families to improve student academic achievement (Mapp & Kuttner, 2013). The U.S. also included a parental involvement component in the Every Student Succeeds Act in 2015, emphasizing that parental involvement is critical to students' growth. These policies and laws have greatly facilitated the exploration of collaborative parenting practices in the United States. In the 1990s, China's education sector embarked on an exploration of collaborative education between homes and schools, with parents and schools as the primary actors. During this time, the concept of "collaborative education" was introduced. Sun (2002) proposed the incorporation of social education into collaborative education. Subsequently, starting from 2010, the government issued a series of policy documents that elucidated the significance and objectives of collaborative education, designating the long-term direction of education reform in China as improving the mechanism of collaborative education among families, schools, and communities.

Currently, research on collaborative parenting among families, schools, and communities encompasses theoretical investigations, practical studies, and the exploration of developmental paths. While numerous studies have examined parenting from the standpoint of moral education and other aspects, it is equally important to investigate teaching practices. In the context of establishing a lifelong learning society, extending the duration of learners' educational journeys also increases the demand for effective teaching. However, the process of promoting and guiding learning frequently encounters obstacles, such as inadequate communication among families, schools, and communities, divergent goals, and ill-defined responsibilities. Consequently, these challenges hinder the establishment of a learning community. Therefore, it is imperative to consider the role of education in human development to gain a profound understanding of human development characteristics and implement appropriate measures.

15.2.2 Current Status of Research on Collaborative Education Between Home, School, and Community

The term "co-teaching" has been adopted from English and is also referred to as "collaborative teaching" and "team teaching" in China. Shaplin (1964) offers the most widely accepted definition of collaborative teaching, stating that it is a form of instructional organization where two or more teachers work together to educate a specific group of students. With the emergence of the concept of collaborative parenting between homes, schools, and community, collaborative teaching has gradually garnered attention in research. The focus has shifted from the teacher-student dynamic to encompass learners, families, schools, and communities as the key participants in collaborative teaching.

Various home-school-community collaborative parenting models have been practiced abroad with different focuses and can be categorized into three types: school-based, family-based, and community-based. The school-based collaborative parenting model originated in the late 1980s in the United States, where the school-based management movement led to the decentralization of educational responsibility and decision-making to local education departments and schools, promoting the participation of parents, communities, and colleges and universities in the process of parenting (Gertler et al., 2012). The school's proactive invitation is seen as a determining factor in the participation of these actors (Dauber & Epstein, 1993). The family-based model of collaborative parenting emphasizes a strengths-based view of the parenting role of parents, especially low-income parent groups. Parents are neither excluded nor seen as the source of student problems, and the combined power of parents is emphasized (Boutte & Johnson, 2014). The community-based model of collaborative parenting seeks to reverse the reality of previous school reforms that focused only on academics and to promote a focus on factors outside of school that can influence student development. These studies provide a viable research direction for home-school-community collaborative education (Johnson et al., 2020).

In recent years, many domestic scholars have explored the role and practical approaches of collaborative education within the context of home-school-community collaborative parenting. Cai et al. (2023) has reimagined the education environment by considering resources, space, technology, and personnel perspective. Gao et al. (2019) have designed personalized education spaces in higher education utilizing cloud-based platforms. Chen (2022) has analyzed the nature of policies related to "double reduction" and advocated for "family-school-community" collaborative education. Ni (2021) has established a "home-school-community" K-12 education reform community by introducing the innovative concept of a "revolving door" and leveraging information technology to develop an online co-parenting platform. However, despite these efforts, there remains a need for more systematic research in the field of home-school-community collaborative education, particularly in exploring collaborative education elements, themes, and mechanisms. The research process of investigating collaborative education independently from general education research still holds significant appeal. Scholars have examined collaborative education extensively, exploring its constituent elements, education characteristics, and value and significance. Spraker (2003) have demonstrated the positive impact of collaborative education on students' academic performance and self-efficacy. Wang (2005) categorized collaborative education modes into typical, support, parallel, and guest modes based on their characteristics. Similarly, Ma (2020) proposed five elements of collaborative education, including the education community, learners, education goals, education process, and education environment, drawing from an analysis of the online education environment.

The research perspective centered on home-society-community collaboration is not yet prevalent. Current research predominantly focuses on dual-subject education within the school, and further exploration of the collaborative education involving the home-school-community ternary subjects is warranted. Understanding the roles and functions of the community and family domains in this context remains insufficient. In conclusion, conducting research on home-school-community collaborative education in the era of artificial intelligence serves to complement existing knowledge in the field of home-school-community parenting. Additionally, it enriches collaborative education research by expanding the subjects of investigation and broadening the scope of inquiry. Therefore, further study is necessary to elucidate the relationships and roles of each element in home-school-community collaborative education within the artificial intelligence era, including the construction of education forms and the development of education pathways.

15.3 The Home-School-Community Collaborative Education Model

15.3.1 Theory Background

15.3.1.1 Overlapping Spheres of Influence

The concept of Overlapping Spheres of Influence was introduced by American scholar Epstein in 1995 as a response to the shortcomings of ecological theory and Cole's social organization theory of social capital. Epstein (2011) posits that the

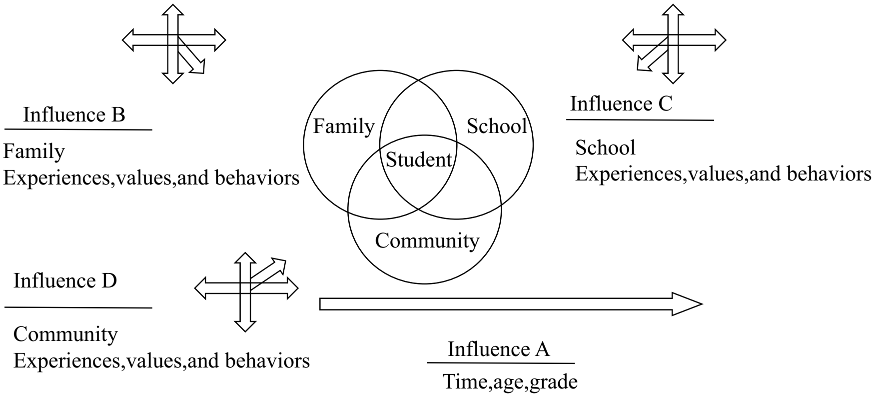

Fig. 15.1 Overlapping spheres of influence

family, school, and community exert the most significant influences on student development. These three entities collectively or individually impact children's learning and development due to the overlapping educational roles they assume which are shown in Fig. 15.1 (Epstein, 2011). Epstein suggests that instead of focusing solely on establishing practical partnerships among families, schools, and communities, it is more beneficial to examine the theoretical level and determine which factors have a greater impact on student development. From a dynamic perspective, this study aims to observe how families, schools, and communities proactively address obstacles arising from subjective and objective factors during the collaborative process.

15.3.1.2 Synergy Theory

Hermann Haken, a professor of theoretical physics at the University of Stuttgart in West Germany, is credited as the founder of synergetic theory, and introduced the concept of synergetics and gradually developed a novel and distinctive research framework. To comprehensively investigate synergetic theory, Haken published works such as "Introduction to Synergetics" and "Higher Synergetics," which contributed to the formation and development of this emerging discipline in the 1970s. Synergetics has since evolved into a significant branch of system science, encompassing multidisciplinary research and offering a comprehensive understanding of systems' transition from disorder to order, including the conditions and laws governing such transformations. Notably, ancient Chinese natural philosophy also emphasized the collaborative and synergistic phenomena among diverse entities, emphasizing the notion that "harmony" arises from the amalgamation of dissimilar elements, resulting in the creation of novel entities (Li, 2008).

15.3.2 *The Elements of Home-School-Community Collaborative Education*

15.3.2.1 Education Subject

Learner

In the era of lifelong learning, the concept of learners has expanded beyond students within the confines of traditional schooling to encompass individuals as active members of society. Consequently, the scope of home-school-community collaborative education needs to be broadened to include all individuals. Leveraging the capabilities of modern intelligent education systems, it becomes imperative to tailor learning goals for learners, encompassing cognitive, skill-based, and emotional aspects, while also aligning these goals with the shared objectives of family, school, and community. This integration facilitates the implementation of collaborative education. To facilitate lifelong learning for a wider range of individuals through the use of AI technology, there is a need to leverage the permeability of family education, sustain and expand the offerings of school education, and effectively integrate resources from community. These efforts are indispensable in fostering a comprehensive and effective learning experience.

Schools

Schools serve as purposeful, planned, and well-organized establishments that exert influential effects on learners. They play a pivotal role in facilitating the synergy of teaching and learning, bridging the gap between family education and community education. On the one hand, schools provide families with guidance on learner development, and on the other hand, they access valuable teaching resources from the larger community (Jia, 2022). However, in the current landscape of collaborative education, schools often face the issue of "responsibility overload." Poor communication channels and divergent goals frequently result in a one-sided perception of home-school collaboration, wherein families are seen as merely cooperating with schools in the education process. Consequently, schools bear excessive responsibility for education (Du, 2021). Collaborative efforts between schools and the community tend to be sporadic and simplistic. Schools primarily seek cooperation with extracurricular educational institutions when they require additional resources, such as science and technology centers or museums, to enhance the educational experience. However, such collaborations often involve one-way utilization of extracurricular educational resources by schools, making it challenging to establish mutually beneficial relationships between schools and social organizations.

Family

Family education serves as the initial and foundational phase of education, serving as the starting point for most learners. However, in practice, school education takes center stage in the educational ecosystem, leading to the relative marginalization and disadvantages faced by family education, resulting in an "absence phenomenon." Persistent miscommunication between homes and schools further exacerbates the challenge of aligning parental teaching goals with those of the school, leading to the negative consequences of fragmented home-school efforts. While formal collaboration between family education and community education primarily occurs through schools, informal occasions often witness weak or even antagonistic connections between family education and community education. For instance, some parents may restrict their children's access to electronic devices to prevent addiction, inadvertently limiting their opportunities to access online learning resources. The rise of the Internet has also blurred the boundaries between family education and community education, facilitating the exchange of educational concepts. Unfortunately, this exchange has also normalized certain unscientific parenting approaches, potentially deepening the antagonism between family education, school education, and community education.

Community

Community education serves as a valuable complement and extension to school and family education, distinguished by its wide-ranging influence and long-term effects. Common venues for community education include libraries, museums, and community schools. However, due to factors such as limited implementation time, inadequate attention, and a lack of clear objectives, social education has not fully realized its potential and exhibits weaknesses in collaborative teaching. Additionally, with the advent of the Internet era, various platforms have become inundated with undesirable information, creating obstacles and disruptions to collaborative education. The era of artificial intelligence offers an opportunity to strengthen network mechanisms, ensures age-appropriate content, recommends suitable resources for learners.

15.3.2.2 Education Space

Education space can be categorized into physical and virtual realms. The profound integration of information technology and education practices has revolutionized the concept of education space, expanding it beyond physical boundaries to encompass a convenient and diverse virtual space. The fusion of these two dimensions forms an interconnected entity. The integration of education spaces has opened up a broader realm for home-school-community collaborative education, contributing to diversified education approaches, enhanced instructional efficiency, and the creation of a favorable ecosystem for collaborative education among homes, schools, and communities (Zhang & Li, 2019). Consequently, communication channels between teachers and parents have become more convenient and efficient, thereby addressing the longstanding issue of poor home-school communication and promoting effective collaboration to support students' learning. Moreover, the integration of education spaces allows students to engage in learning activities alongside their parents, establishing a protective shield against exposure to undesirable online content. Furthermore, the abundant education resources provided by the community can enrich school curricula. For instance, immersive interactive experiences facilitate the connection between academic concepts and real-life situations, rendering abstract ideas more tangible and actionable (De et al., 2019). Furthermore, the integration of education spaces expands students' knowledge, elevates the significance of schools, enriches the teaching evaluation system, fosters ongoing collaboration between schools and community, and facilitates students' multifaceted development.

15.3.2.3 Education Resources

In general, education resources include textual, physical, activity, and information technology resources. By integrating these resources and establishing a high-quality platform, collaboration among homes, schools, and communities can be strengthened, effectively balancing their respective roles. Community education offers abundant activity and physical resources. However, in previous times, these resources were predominantly employed by schools without establishing long-term collaborative mechanisms, often limited to showcasing outcomes of demonstrative activities. In practice, schools have the potential to establish enduring collaborations with social organizations and parents, collaboratively establishing educational exhibition centers that prioritize the integration of research, learning, and education. This collaboration should involve discussions on educational approaches, resource sharing, and mutual benefits, effectively leveraging social resources. Meanwhile, school education predominantly relies on textual and information resources. However, there is limited circulation of teaching resources between different schools, leading to an inequitable distribution of educational resources. To address learners' diverse needs and reduce resource disparities, it is crucial to further integrate collaborative education resources from homes, schools, and communities. This integration will establish a platform that facilitates the sharing of resources. Therefore, leveraging technologies such as user recommendation algorithms and cloud storage becomes necessary to provide learners with rich and adaptable learning resources. Learners can use the sharing platform to obtain a wide selection of educational resources not only from schools but also from social libraries, families, and other sites. This enables tailored learning at any time and from any location, increasing learners' access to a wide range of educational resources.

15.3.2.4 Education Data

Education data refers to the data collected during education activities, encompassing user data and resource data (Cai et al., 2023). User data, also known as learner data, involves collecting relevant information during the education process to analyze learner engagement and education progress. This includes attribute data, multimodal data, and social data. On the other hand, resource data pertains to the data generated when utilizing education resources and the data obtained through meta-analysis of these resources. It includes spatial data, equipment data, and other relevant information. Resource data provides insights into the quality and popularity of education resources to some extent. Pedagogical data play a crucial supporting role in home-school-community collaborative education, expanding the scope of learner evaluation and monitoring beyond the confines of the school. For instance, comprehensive online learning data and resource usage data can be gathered through online data acquisition systems, enabling the creation of a multidimensional learner profile system. This system facilitates the development of more accurate and personalized learner profiles (Zou & Wu, 2023).

15.3.2.5 Technology

Common artificial intelligence technologies encompass recommender systems, natural language processing, data mining, and cloud computing. Technological advancements have the potential to optimize education practices and inject fresh vitality into home-school-community collaborative education. Firstly, the continuous iteration and updates of AI technology facilitate the equalization of education resources and help mitigate educational inequalities. For instance, the advent of cloud classrooms and MOOC platforms enables learners of all backgrounds to conveniently access a wealth of learning resources. Secondly, AI technology fosters the integration of education environments across homes, schools, and communities, transcending age boundaries and facilitating education activities in various settings. This effectively resolves the issue of limited spatial and temporal alignment among homes, schools, and communities, thereby reducing the costs associated with collaborative education and enhancing communication efficiency. Moreover, the rapid development of artificial intelligence technology enriches education resources and expands education spaces, thereby popularizing personalized learning and establishing a solid foundation for lifelong learning.

15.3.3 The Home-School-Community Collaborative Education Model

Based on the analysis of the aforementioned elements and drawing from the theories of overlapping domains of influence and synergy, the Home-School-Community collaborative education model is proposed, which is shown in Fig. 15.2. In this model, the learner, family, and school collectively collaborate, with the learner's development as the shared goal of this collaboration among family, school, and community. The elements of space, technology, resources, and data serve as crucial components supporting this collaboration, ultimately enhancing the efficiency of education processes.

15.3.3.1 Subject Relationship

In the entire home-school-community collaborative education system, the learner assumes a central role, with the family, school, and community serving the learner. The theory of overlapping domains of influence highlights the synergistic impact of home, school, and community, while recognizing the distinct influences of each entity. Therefore, optimizing collaboration among families, schools, and communities requires acknowledging and respecting the equal status of these entities. Regarding parents, it is crucial to first recognize the subjective role of parents, affirming their importance at the policy level. Concerning the school, it is essential to clarify its distinctive features, such as providing professional subject-based education that enhances students' subject literacy and overall development. Additionally, schools should leverage their unique influence by capitalizing on their strengths and addressing their limitations. This involves creating ample space for family education to impart moral values while effectively delivering subject-specific education. As for the societal dimension, the government and relevant communities must harness

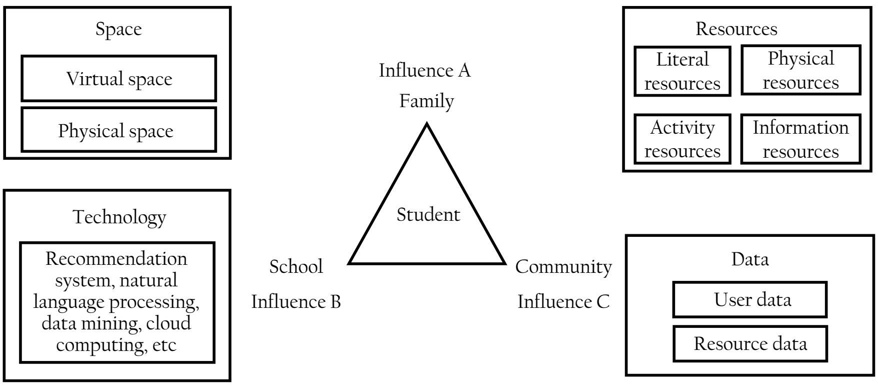

Fig. 15.2 Conceptual model

their ability to integrate the strengths of all stakeholders. By implementing effective educational supply channels and developing robust management and operational systems for home-school-community collaborative education, the engagement of the community may be guaranteed, leading to a greater influence of community education.

15.3.3.2 Role of Elements

Space, data, resources, and technology serve as foundational elements that support home-school-community collaborative education. Space acts as a vital conduit for sharing educational resources, driving innovation in collaborative education models, and expanding the availability of educational resources. For instance, the establishment of master teacher studios, virtual factories, and learning communities enables open sharing services across classes, schools, and communities. Such initiatives facilitate the implementation of information-based teaching and learning innovations, transforming resource services from specific educational contexts to broader educational domains. Furthermore, data plays a crucial role in creating comprehensive learner profiles, which form the basis for resource allocation, timing identification, approach exploration, and pathway development for learning support services. Leveraging artificial intelligence and big data technologies, educational data can be unified, standardized, and scientifically managed within the framework of collaborative education involving homes, schools, and communities. This enables accurate needs assessment for collaboration and the formulation of effective collaborative strategies based on data analysis, thereby fostering a robust home-school-community linkage mechanism. Resources include a vast array of learning support services, such as the direct provision of teaching materials, curriculum resources, learning tools, supplementary support for learning strategies, historical data resources, and indirect support for emotional well-being. For instance, providing services to learners experiencing emotional distress can significantly improve their learning experiences. Technology plays a crucial role in facilitating the transformation of teaching and learning processes. Therefore, future learning centers should pay careful consideration to the incorporation of artificial intelligence applications such as ChatGPT, enabling students to engage in more extensive and in-depth independent learning. The adoption of artificial intelligence can provide valuable support for personalized instruction, facilitating the process of idea generation and creative thinking among students. This paradigm shift prioritizes students as the focal point of the learning process, facilitating the adoption of an authentically student-centered methodology.

15.4 The Forms of Home-School-Community Collaborative Education

Education form refers to the theory, objectives, content, structure, mode, and other aspects of the comprehensive system formed in the process of education, which is the external manifestation of the education culture, dynamic, generative, and developmental. Education form is the organic fusion of various factors presented by a state of character, and is based on the teaching and learning mode to produce education expression. Different education forms will emerge in certain education practices as a result of various combinations of education concepts, objectives, teaching and learning styles, and other factors. As shown in Fig. 15.3, the collaborative education form of home, school, and community in the age of artificial intelligence primarily refers to the comprehensive system of education formed by education goal, education environment, education subject, education process, education resources, and education evaluation.

15.4.1 Generative Education Objectives

Discussions on "education objectives" began at the beginning of the twentieth century. Since the concept of education objectives was introduced in China, scholars in China have made different interpretations of it. Under the influence of the representatives of Western pedagogical theories, such as Bloom, Kraswall, and Harlow,

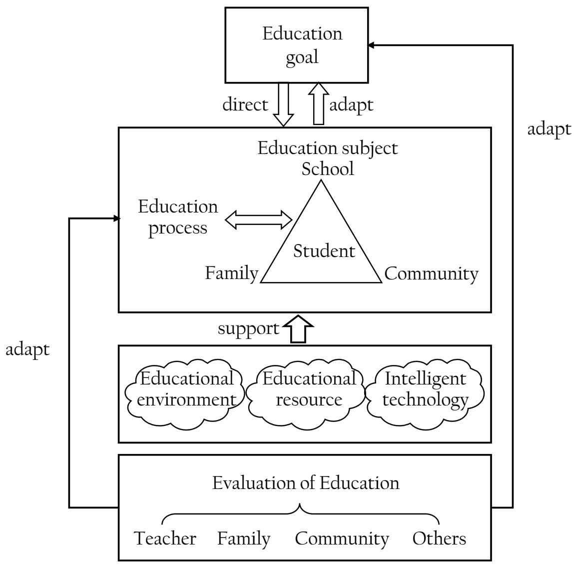

Fig. 15.3 The collaborative education form of home, school, and community

the education objectives in China have gone through a transformation from "double-base" and "three-dimensional objectives" to "core literacy." Core literacy is further divided into three dimensions: independent development, social participation, and cultural foundation. No matter what kind of education objectives, it is advocated that we should gradually get rid of the predefined target value orientation, and conduct further target structure based on variable education activities (Liu et al., 2022).

The "non-preset" nature of home-school-community collaborative education goals empowered by artificial intelligence refers to the iterative optimization and continuous generation of education goals following the learning effect and learning process of students, thus prompting the education body to carry out education activities around an identical education goal. The education objectives should focus on giving full play to the advantages of human beings, and cultivating and developing students' "unique human ability" and "artificial intelligence ability." The "unique human ability" refers to the unique thinking ability and emotional attitude of human beings, including critical thinking, creative ability, collaborative communication, aesthetic literacy, etc. The "artificial intelligence ability" refers to the strengthened rational thinking ability of human beings, which complements and improves the limitations of human thinking, such as the ability of in-depth learning and the ability of computational thinking (Sun, 2021). Therefore, in the era of artificial intelligence, the education objectives of home-school-community collaborative education can be divided into preset objectives and generative objectives. In determining the goals of home-school-community collaborative education, the school is the main body, and the family and the community are the assistants. The school guides the family and the community in creating the preset goals—that is, the goals that must be attained by every student—in order to realize the overall development of the students. These goals are based on the curriculum standards and students' characteristics. Furthermore, schools must guide families and communities in the use of artificial intelligence to achieve student-generated goals. Generated goals can realize students' personalized development, such as using multimodal technology to record various kinds of students' learning data, analyze students' learning status, and then determine the teaching goals of the next step of teaching for the students. In short, the generation of students' wisdom is a long-term and implicit process. Through the continuous guidance of preset goals and generated goals, home-school-community can cultivate students' innovative learning, make students more capable of learning, and drive students to improve in all aspects.

15.4.2 Virtualized Education Environment

The education environment is a very large and complex system composed of many factors, which not only includes the physical environment such as the facility environment, the natural environment, the space–time environment, but also includes the socio-cultural and psychological environment that has a certain impact on students' cognitive, emotional and behavioral habits in learning. It can be said that the quality of the education environment determines the effectiveness of education activities to a certain extent. Therefore, in order to improve the overall effect of education activities, families, schools, and communities should create a relaxed and innovative education environment for students, maximize the positive functions of the education environment, and achieve the optimization of the education environment. Education environment is the basis for activities, and in the era of artificial intelligence, the education environment is no longer limited to the traditional classroom, but infinitely extended to the virtualized space.

In the era of artificial intelligence, the education environment is externally embedded with artificial intelligence technology, and the data-connected environment space acts as an intermediary, enabling the seamless coupling of the physical and virtual spaces of the teacher and the learner, and constructing a hybrid complex space where student learning and educator teaching coexist, thereby promoting the reform of home-school-community collaborative education. Intelligent technologies, such as 5G networks, XR technologies, etc., provide the primary support for the transition of physical to virtual education environments. The intelligent technology-enabled teaching environment refers to the augmentation of the traditional educational setting with cognitive capabilities, allowing for flexible, dynamic, and personalized services to support collaborative education between humans and machines (Xie et al., 2021). 5G network, XR technology can provide schools and families with high-fidelity and low-latency interactive experiences, allowing for the creation of real-world teaching situations, while also realizing school and family linkage teaching and promoting high-quality resource usage. Knowledge mapping, pattern recognition, and machine learning technologies can realize real-time refinement and dynamic push of classroom teaching resources, provide a resource base and bridge for communication among schools, families, and communities. Digital portrait and digital twin technologies can realize dynamic analysis of student learning conditions and real-time visualization of student learning conditions based on multimodal data fusion. Digital image and digital twin technology can realize dynamic analysis and real-time visualization of students' learning situations based on multimodal data fusion, and provide support for dynamic portrait evaluation of the effect of home-school-community collaborative education.

15.4.3 Interactive Education Subject

In the age of intelligence, the existence of machine learning, intelligent algorithms, knowledge mapping, NLP (natural language processing), and other technologies has further broadened the concept of the education subject and extended the connotation of interactivity. On the one hand, it realizes the transformation of the education subject from "teacher-student" to "human–computer"; on the other hand, interactivity is no longer just verbal communication between human beings, but also a kind of interaction for the whole education system. There are four kinds of relationships between human beings and modern technologies: background, interpretation, embodiment, and otherness. However, the emergence of intelligent technology may weaken or even eliminate the role of the human subject. Therefore, it is necessary to correctly view and deal with the subjective relationship of "human–machine," so that the interactivity can return to the human itself, i.e., to develop technology based on the value of individual human beings. Teachers, parents, community members, and other home-school-community tripartite personnel should establish the correct concept of the development of the education subject, and rationally utilize artificial intelligence to promote interactive learning. On the basis of ensuring the normal education process, home-school-community tripartite personnel should actively promote the achievement of multilateral education activities to further stimulate the maximum potential of education generativity. On this basis, appropriate education methods should be selected and education objectives should be formulated according to the individual needs of students, so as to improve the quality of education. At the same time, the relationship between "man and machine" should be viewed correctly. With the use of artificial intelligence, the tripartite labor force of home, school, and community will be liberated to a certain extent, and they can focus more time and energy on students' emotional participation, complex interaction activities, and so on, so as to further improve the education efficiency.

With the support of artificial intelligence technology, firstly, the equal interaction between subjects is realized in the phase and understanding of multiple subjects and dialogue, to realize the conceptual identity, the learning of knowledge, and the acquisition of wisdom. Secondly, the use of artificial intelligence technology helps to build an education environment of subject interaction and dialogue, which is conducive to the school, family, community, and students to play their respective subjectivity. Additionally, schools, families, society, and students can use artificial intelligence technology in the teaching process to analyze the scientific nature of educational ideas and models, then promote them to keep up with the times and continuously realize creation and development (Jiang, 2016).

15.4.4 Dynamic Education Process

In the educational process, AI can design learning problems based on personalized analysis of learners' data that are appropriate for the students' abilities and knowledge levels, provide appropriate help and guidance, and mobilize situational problems and learning resources that are appropriate for the students' personalities in real time. AI is a technology that spans across generations and possesses robust capabilities for data processing and analysis. It has surpassed the importance of previous information technology tools and can assist humans in managing tasks and engaging in decision-making processes. AI has the ability to gather learners' data and create a comprehensive database containing their learning records, preferred learning styles, intellectual traits, and other relevant information. Additionally, it can intelligently generate digital models of learners and continuously update the data parameters during the teaching process. Therefore, AI is based on big data and can analyze the learning status of students and learning effects in the education process with data mobilization as the core (Xu, 2022). Big data has greatly promoted the development of AI in the field of education, through the generation of visual data can effectively build accurate student profiles, the formation of personalized learning mechanisms. The multimodal data generated during the teaching process serves as the data support for education, and AI devices can analyze and summarize the data generated during the education process to obtain the corresponding conclusions and feedback, and then make real-time adjustments.

In the era of AI, home-school-community collaborative education takes the AI collaborative platform as the basis for integration to carry out education activities, realize the dynamic development of the education process. School education is still in the main position, family education is the foundation and support of school education, and community education is the expansion and extension of school education and family education. In the process of school education, artificial intelligence assists teachers in organizing educational materials. Through the complementary advantages of human–machine cooperation, teachers no longer need to engage in tedious, mechanical, and repetitive transactional work, but rather focus on individual emotional communication, interpersonal interaction, and other unique nurturing roles that cannot be accomplished by machines, and shift the focus of the education process to nurturing people. In addition, teachers can make full use of the advantages of artificial intelligence, knowledge "presentation form" and "content performance" become more attractive, infectious, and vitality, so as to attract the attention of students. With the help of AI, teachers can make full use of resources and provide good guidance to improve education process. Parents can monitor the education process in real time through AI technology, and utilize the home-school-community AI collaborative platform to provide real-time feedback and suggestions. The community can cooperate with the school to build a virtual teaching practice base using AI technology, so that the development of students can be adapted to the needs of society. In this entire education process, the activities of the school, family, and community are tracked and recorded in real time through AI technology, and then analyzed and fed back in real time, thus promoting the dynamic optimization of the education process.

15.4.5 Shared Education Resources

Education resources are necessary for the implementation of education, and whether they can be efficiently utilized is a key factor affecting the efficiency of the classroom. With the rapid development of intelligent technology and the Internet, educators only need to enter keywords in intelligent search engines to obtain education resources they need across the limitations of time and space, thus improving the effectiveness of classroom teaching. Furthermore, these educational resources undergo frequent updates, so efficiently ensuring the currency of home-school-community collaborative education. Therefore, the integration of AI technology can effectively ensure the scientific and timely selection of education resources, thus strengthening the connection between theoretical knowledge and real life, deepening students' understanding and cognition of phenomena, and optimizing the education effect.

School education has rich education resources, whereas family education and community education resources are relatively fragmented and unsystematic, so in order to promote the development of home-school-community collaborative education, we must promote the integration and sharing of home-school-community collaborative education resources. Families, schools, and communities can use AI technology to build an education resource-sharing platform, which can systematically integrate the resources uploaded by schools, families, and communities and analyze and give feedback to them to achieve efficient use of education resources in different scenarios. Families, schools, and the community can then gain access to the platform, obtain the education resources they require in real time, and engage in educational activities.

15.4.6 Multiplex Education Evaluation

Education evaluation is the assessment of the outcomes of educational activities. It is an essential tool for measuring the benefits and drawbacks of education, reflecting on the effectiveness of education, and promoting the equity of education. From the perspective of AI home-school-community collaborative education, education evaluation can promote home-school-community tripartite attention to students' development and improvement at the level of emotion, attitude, value, and social practice ability. Diversification of education evaluation, on the other hand, assesses students' learning outcomes in a practical way, combines teaching practice and evaluation, and focuses on students' unique experiences in the education process. These experiences are meaningful and positive for students' development. This makes the assessment objectives no longer limited to students' learning outcomes, but focuses on students' mastery of practical skills.

The integration of artificial intelligence and big data as fundamental technologies has significantly impacted the field of education evaluation. However, this type of evaluation primarily emphasizes standardized abilities and literacies that can be quantified through data analysis, neglecting the exploration of human subjectivity. Consequently, educated individuals are reduced to mere statistical data and treated as objects that can be quantified, thereby diminishing the depth and intricacy of human experiences (Jin, 2019). Given this perspective, scholars have put forth the proposition that educational evaluation ought to place greater emphasis on individual characteristics and differentiated growth. Furthermore, it is suggested that there should be increased focus on the capacity for individual knowledge application and innovation. Consequently, a developmental approach to education evaluation that encompasses both outcomes and processes should be established (Gao & Lan, 2018). In the era of artificial intelligence, the education evaluation of home-school-community collaborative education is divided by education subjects, including school evaluation, family evaluation, and community evaluation.

For school evaluation, on the one hand, schools can collect monitoring data, determine education evaluation indexes, and establish evaluation models that can be quantitatively assessed through artificial intelligence. Teachers can collect and analyze teaching multivariate data through AI to discover problems in the process of teaching implementation and deficiencies in teaching design in time, and then make the necessary adjustments to achieve continuous optimization of teaching. On the other hand, schools can lead families and communities to use blockchain technology to construct a dynamic comprehensive student evaluation system. Blockchain technology is a kind of distributed bookkeeping technology, which can also be regarded as a shared database, containing information with the characteristics of decentralization, truthfulness, traceability, and transparency, etc. Accordingly, the student evaluation system constructed on the basis of blockchain technology can give students, teachers, parents, communities, and other subjects the corresponding authority to enter the system to implement the evaluation and get feedback in real time, so as to realize the multi-display of evaluation subjects and the dynamization of evaluation results. The AI-based comprehensive student evaluation system can track and record various indicators of students and each recorded data has a time line, such as academic development, moral development, psychological status, teacher evaluation, etc., so as to realize the process evaluation of students (Sun, 2021).

For family evaluation, firstly, parents can cooperate with the school to build a student evaluation system, obtain system privileges, have real-time access to students' learning data, and upload student data collected in daily life to obtain real-time feedback. Secondly, parents can also be inspired by the tracking records of learning indicators in the student evaluation system, as well as the teacher evaluation and community evaluation, to obtain the latest educational concepts to achieve better educational results, and thus promote the more comprehensive development of students.

Community evaluation takes the community as the main body. First of all, similar to the family evaluation, the community can cooperate with the school to build a student evaluation system to obtain relevant data and evaluation and real-time feedback. In addition, community evaluation can also use the relevant data of the student evaluation system as data support to analyze the current situation and future development direction of community education, and thus promote the development of community education.

15.5 The Practical Path of Home-School-Community Collaborative Education

15.5.1 The Construction of Synergistic Platform Between Home, School, and Community

The construction of a collaborative artificial intelligence platform including family, school, and community education, and the integration of various forms of education and resources are not only conducive to the optimal allocation of resources, but also strengthen the links and interactions between various types of educational resources, providing the convenience and conditions for their articulation in space and time. The organic connection between family, school, and community education is the basis for the development of "three-in-one" education (Han, 2021).

The establishment of a robust AI collaboration platform for collaborative education between homes, schools, and communities serves to foster ongoing connections among these entities. Additionally, this platform can function as an expanded educational environment, thereby facilitating the advancement of education practices. The initial step in constructing the AI collaboration platform involves establishing a consensus among the family, school, and community. This consensus aims to define the operational and management mechanisms of the platform, as well as other relevant aspects. The objective is to ensure that the constructed AI collaboration platform effectively addresses the requirements of all three stakeholders. Secondly, the construction of a collaborative artificial intelligence platform that includes family, school, and community education is aimed at integrating the various forms and resources of education, promoting the optimal allocation of resources, and enhancing the links and interactions between the various types of educational resources. Such a platform facilitates and provides conditions for the organic convergence of family, school, and community education, and serves as the basis for the implementation of the "trinity" of education. Thirdly, it is of great significance to build a stable AI collaborative platform, which not only maintains the close connection between home, school, and community, but also serves as an extended education environment and helps the development of education activities. Through the AI collaboration platform, families, schools, and communities can work better together, share educational resources, and promote educational innovation and development, thus realizing the goal of all-round education.

15.5.2 The Promotion of Synergistic Education Between Home, School, and Community

15.5.2.1 Relations Between Home, School, and Community

In the process of cultivating talents, education is of vital importance. However, education is not limited to school education, but includes a combination of family education, school education, and community education. Family education focuses on moral cultivation and helps learners develop good behavioral habits and healthy mental qualities. School education mainly teaches specialized knowledge and cultivates professional and technical talents. Community education, on the other hand, is characterized by its epochal nature, and its connotation and extension are constantly changing and expanding as society progresses. The synergistic teaching of family, school, and community cannot be separated from the close cooperation among these three. The synergistic linkage of them can promote the development of the whole educational work. The collaborative co-education of families, societies, and schools requires the establishment of a new type of partnership, which is conducive to the all-round growth of children.

Family education is the foundation of school education, school education is the key stage of the entire educational process, and community education is an extension of family and school education. To summarize, family education, school education, and community education are closely linked, mutually influential, coordinated, inseparable, and indispensable. They are integrated, jointly influencing the growth and development of the individual, while at the same time being independent of each other, each bearing an irreplaceable educational responsibility. Only by simultaneously concentrating on these three modes of education and creating a harmonious educational environment can we more effectively support the development of modern education and the cultivation of more modern talents.

15.5.2.2 Strategies for Enhancing Home, School, and Community Education

Home Education

Firstly, improve the quality of parents. Parents are the first teachers of students, and their exemplary role in words and deeds cannot be ignored. Therefore, home-school-community collaborative education needs to focus on cultivating the quality of parents. Parents should pay attention to their own behavior, cultivate sincere communication, be good at interpersonal relationships, and treat others with courtesy. Excellent moral quality will subconsciously have a positive modeling effect on students. Secondly, change the parents' backward educational philosophy. With the development of science and technology and economy, society is progressing rapidly, but some parents' education concepts are still lagging behind. Parents should address on the importance of students' participation in team activities and interpersonal relationships, and cultivate students' spirit of solidarity, cooperation, and willingness to help others. Thirdly, improve education methods. Parents should not adopt rough solutions when facing students' unreasonable behavior. Instead, they should analyze calmly and guide students to make changes by means of persuasion. Opinions gained through reflection and guidance are more profound than those arrived at through violence. This gentle and rational approach to education can establish a favorable atmosphere of collaboration between home, school, and society and promote the overall development of students.

School Education

Firstly, infiltrate moral education into classroom. Teachers should infiltrate moral education into the classroom teaching, and at the same time integrate real-life situations, leading students to solve and deal with the problems with correct thinking, so as to further improve the moral quality of the students. Secondly, permeate moral education in activities. Incorporating moral education into school activities can be achieved through various means. For instance, teachers can play a pivotal role in guiding students by organizing screenings of educational films. Following these screenings, students can be prompted to reflect on the movie's aftermath and express their emotional responses. Thirdly, pay more attention to lag behind student. Lag behind students have a specific area for growth, and teachers need to be properly directed to comprehend their thinking before providing the necessary support. Teachers should prioritize their focus on children who exhibit academic difficulties, engaging in more communication with them, comprehending the underlying causes for their academic setbacks, devising appropriate strategies to assist them, and fostering their overall development.

Community Education

First, monitor the environment outside the school. Schools need to communicate with the local police station and the government to strengthen the supervision and inspection of entertainment venues and cultural venues near the school, to prevent the emergence of illegal as well as affect the physical and mental health of the students, to provide protection for the healthy growth of students. Secondly, coordinate with the government to increase the financial investment in public facilities. Communities can submit applications to the government for more investment in public service infrastructure, such as the establishment of township libraries or youth cultural and sports activity centers. Additionally, communities can arrange frequent visits for students to these facilities, aiming to enhance their knowledge and broaden their horizons. Thirdly, unify the home and school to educate the students. The community serves as the principal avenue via which students can engage with and comprehend society. Participation in community survey activities affords students the opportunity to acquire knowledge of social norms, gain insights into the conditions prevailing within the community, and foster the development of their social responsibility. Furthermore, the community serves as a vital connection between educational institutions and families. For instance, engaging community events can be orchestrated, inviting both schools and families to partake in these activities. This fosters a collaborative partnership among families, schools, and the community (Chen, 2020).

15.5.3 The Promotion of Synergistic Resources Between Home, School, and Community

In the era of artificial intelligence, education resources are very rich, but all kinds of education resources are intricate and diverse, and they will be difficult to be applied to the collaborative education of home-school-society if they are not integrated. The resources involved in this chapter mainly include text resources, physical resources, activity resources, and informatization resources. Through certain online and offline collaborative means, the home-school-community can jointly promote the integration of resources and systematize the resources, which is more conducive to the development of home-school-community collaborative education.

15.5.3.1 Integration of Family and School Resources

The comprehensive utilization of family education is crucial in facilitating the development of children and adolescents. Educational institutions have the capacity to leverage their professional expertise in order to offer advice on matters pertaining to family education. This includes assisting parents in cultivating a positive home environment and transmitting or cultivating a healthy family culture. Parents from different professions and positions can also become a very important resources in school education by coming to school and participating in school activities.

15.5.3.2 Integration of Community and School Resources

As the focal point of social culture, schools can expand the availability of school resources to the community. For instance, facilities such as libraries, sports stadiums, and classrooms are provided to parents or local citizens for the purpose of studying. Similarly, the societal context serves as the milieu within which students reside, and it is imperative to grant them the opportunity to delve further into social settings in order to gain vocational experience. Exhibition halls, children's palaces, red tourist attractions, and other community venues that offer enriching activities should be made accessible to educational authorities, enterprises, institutions, and social workers. By leveraging their professional expertise, social workers can collaborate with schools and families to organize educational activities. This collaborative effort aims to address the insufficient resources available for mental health education in schools, while also contributing to the enhancement of social influence of community venues. Despite the inherent complexity and absence of systematicity and specialization in the community venues, they remain valuable resources with significant potential for the advancement of mental health education.

15.5.4 The Construction of Synergistic Evaluation and Feedback Mechanism Between Home, School, and Community

The purpose of evaluation and feedback on home-school-community collaboration is to gain a clear understanding of the current state of collaboration and identify any existing deficiencies. They aim to offer valuable information and serve as a reference for enhancing the collaboration mechanism in the future. Evaluation and feedback take a key role in enhancing the efficacy of the home-school-community collaboration mechanism. It is imperative for teachers to possess the capacity to assess the effectiveness of the collaboration between home, school, and community. Evaluation and feedback play a crucial role in improving the process of collaboration between home, school, and community. Furthermore, it is essential that educators demonstrate the ability to assess the effectiveness of the partnership among the household, educational institution, and community. On the one hand, the relevant members of the home-school-community should have a comprehensive understanding of the capacity to determine the impact of home-school-community synergy. The current effect of home-school-community synergy is an essential criterion for determining whether the extant program design for home-school-community synergy is reasonable and whether the synergy path is applicable. On the other hand, relevant members, especially teachers, should be able to provide feedback on the existing problems of the synergy, so as to provide positive feedback support for the synergy and realize the virtuous cycle of the overall synergy process.

The advent of artificial intelligence has provided a basis for the integration of educational assessment into a novel digital technology platform. In this context, the utilization of an artificial intelligence platform is advocated to facilitate the generation of diverse scenarios. This, in turn, expedites the reformation of talent development approaches and instructional methodologies by means of comprehensive teaching and management applications. Additionally, it enables the dissemination of abundant educational resources and the establishment of effective communication channels among households, educational institutions, and the wider society. Furthermore, it facilitates the refinement and intellectualization of evaluation feedback. Lastly, the transmission of feedback mechanisms is effectively executed through the utilization of artificial intelligence's data mining and automatic analysis capabilities.

15.6 Conclusion

Taking the era of artificial intelligence as the background, the present study takes overlapping influence domain theory and synergy theory as the theoretical basis, and analyzes the current situation of home-school-community collaborative education. Firstly, it sorts out the relationship among family, school, and community and constructs a home-school-community collaborative education model from the aspects of subject, space, resources, data, and technology. Secondly, the collaborative education form of home, school, and community is proposed with the following elements: education goal, education environment, education subject, education process, education resources, and education evaluation. Finally, this research sets forth the practical path of the home-school-community collaborative education model in the context of artificial intelligence, with the aim of enhancing the effectiveness and recognition of home-school-community collaborative education.

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Chapter 16
A Design Approach of Education for the Seniors Supported by Digital Technology

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Abstract This chapter focuses on the design and practice analysis of education for seniors based on information technology. The research first utilizes Maslow's hierarchy of needs theory to analyze the educational needs of seniors and consequently establish the functional positioning of education for seniors. It then explains four organizational forms in the field of education for seniors, including the universities for seniors, lifelong learning institutes, community centers continuing education programs, and online learning platforms, while presenting exemplary cases and practices from different countries. Lastly, this research introduces the application of new technologies in the education of seniors, exploring the utilization of artificial intelligence technology, virtual reality/augmented reality technology, and mobile network technology, as well as analyzing future development trends. The chapter aims to provide valuable theoretical and practical experiences for managers and educators in the field of education for seniors.

16.1 Introduction

Over the past few decades, the world has experienced a remarkable shift in population dynamics, particularly with the rise of the aging population. This demographic change brings both challenges and opportunities for societies across the globe. It has become increasingly important to promote active and healthy aging while providing lifelong learning opportunities for older individuals. In response to these needs, universities for seniors, also known as colleges for seniors or lifelong learning institutes, have emerged as crucial institutions. These universities offer a diverse array of courses and programs specifically designed to cater to the interests and abilities of older learners. By promoting personal development, enhancing skills, and fostering social connections, universities for seniors contribute to the overall well-being and

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enrichment of seniors (Zhang, 2010). The development and positioning of universities for seniors differ significantly from regular universities. The core objective is to enhance the design of education for seniors through three key components. The first part designs the functional positioning model of education based on Maslow's hierarchy of needs theory. The second part explains four main organizational forms of education for seniors. The third part introduces innovative technologies used in education for seniors.

16.2 Hierarchy of Seniors' Needs

Abraham Maslow, an American psychologist, proposed a "Hierarchy of Needs Theory" in 1943, which categorizes human needs into five levels. It begins with basic physiological needs and gradually progresses to safety, belongingness and love, esteem, and self-actualization. These needs are arranged in a pyramid structure known as Maslow's Hierarchy of Needs. According to this theory, lower-level needs must be fulfilled before higher-level needs. Once individuals have fulfilled their physiological needs, such as obtaining food, shelter, and health, they start to seek security, which includes stable employment and physical safety. Subsequently, they strive for needs related to belongingness and love, which involve building positive relationships with family and friends. Esteem needs, such as recognition, respect from others, self-esteem, and self-confidence, follow suit. Finally, individuals pursue self-actualization needs, aiming to realize their potential and pursue their own goals. Based on Maslow's hierarchy of needs theory, we analyze the hierarchy of needs for seniors and explain the educational needs of the seniors. (see Fig. 16.1).

16.2.1 Physiological Needs and Safety Needs

Physiological needs are the most fundamental needs, encompassing necessities such as food, water, sleep, and other essential survival requirements. Without fulfilling these needs, higher-level needs cannot be addressed. When considering the establishment of a university for seniors, it is crucial to prioritize the basic needs of older adults, including their health, nutrition, and physical activity.

Safety needs encompass physical, psychological, and social safety. Seniors require a stable and secure environment, including personal safety, physical and mental well-being, and convenient living conditions. In the establishment of a university for seniors, addressing the safety needs of seniors is crucial. Safety needs represent a significant level in Maslow's hierarchy of needs, encompassing individuals' requirements for personal safety, stability, law and order, and a secure and supportive living environment (Feng & Wu, 2022). As a space that offers learning and social opportunities, the university for seniors must prioritize the safety and security of the seniors on campus, ensuring their physical and property well-being.

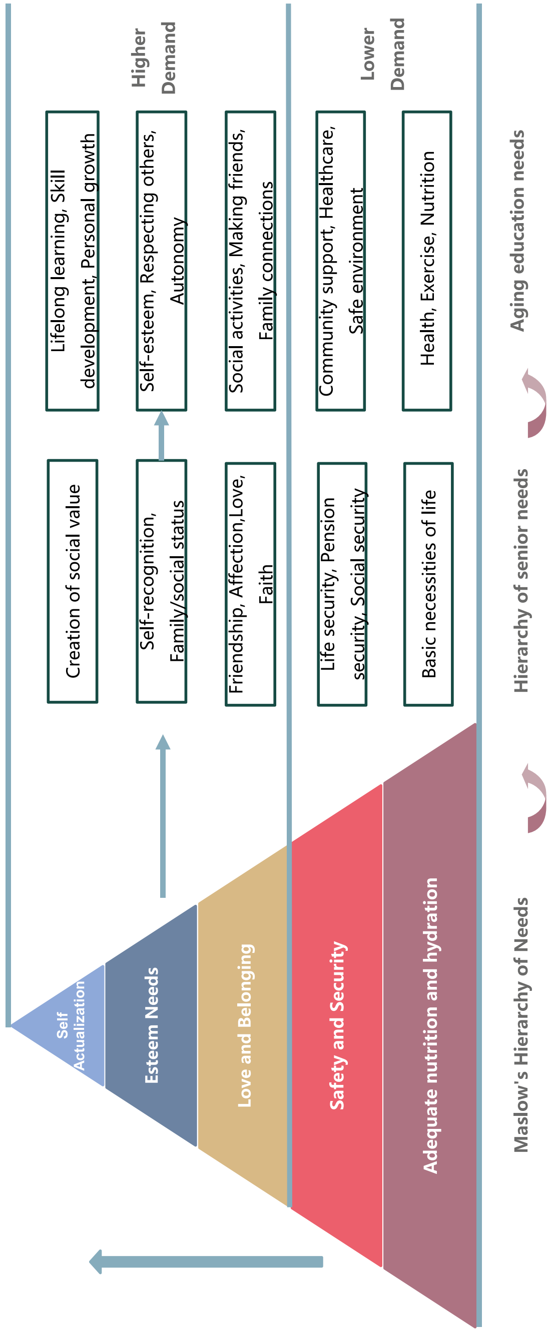

Fig. 16.1 Aging education needs model based on Maslow's hierarchy of needs theory

In the process of establishing a university for seniors, various considerations need to be taken into account to ensure a safe and supportive environment for the seniors. Among campus security, equipment and facility safety, emergency response preparedness, and psychological support are the key aspects that should be addressed.

To ensure campus security, it is imperative to implement comprehensive measures, including security patrols, surveillance systems, and disaster warning systems. Such measures are paramount in maintaining safety and order on campus. Additionally, the equipment and facilities used by the seniors should adhere to relevant safety standards, undergoing regular inspections and maintenance to prevent accidents and safeguard their well-being. Establishing an emergency response system, trained staff and volunteers equipped with first aid skills is crucial in enabling prompt assistance and proper handling during accidents or emergencies. That will be able to timely assistance and proper handling in the event of accidents or emergencies. Collaboration with relevant departments and agencies is essential to establish effective cooperative mechanisms. Crime prevention and privacy protection should also be prioritized. This entails providing safety awareness education, training, and guidance on crime prevention and personal privacy protection. Measures to protect personal information and guard against online scams and harassment are crucial to ensure the safety and privacy of seniors. In addition to physical safety, psychological safety, and support should be provided to seniors. The provision of psychological counseling services and the creation of a friendly and supportive learning atmosphere will foster a sense of respect, acceptance, and care for older learners, enhancing their overall well-being and promoting personal development. By strengthening safety measures and creating a safe and comfortable learning environment, a university for seniors can instill a sense of security and confidence among seniors, thereby facilitating their engagement in learning and social interactions and fostering their personal growth. Furthermore, a safe learning environment will attract more older adults to participate in education for seniors, contributing to the development and prosperity of universities for seniors.

Green Oasis College in the United States is a nonprofit organization that offers various learning and community programs designed for adults aged 50 and above. Their course offerings cover health, culture, technology, and social domains, and focus on providing education and research related to safety (Hendrikx et al., 2011). For example, they offer a course called "Safety Needs Assessment" where students learn how to conduct safety needs assessments and identify safety challenges and risks faced by organizations or communities, including identifying potential threats and assessing the urgency of safety needs while providing corresponding solutions. In addition, the "Safety Policies and Procedures" program focuses on understanding and developing appropriate safety policies and procedures to ensure organizations and individuals can address safety needs. Students learn how to formulate and implement safety policies while cultivating compliance and safety awareness. The course "Cybersecurity" explores the needs and challenges related to cybersecurity, teaching students how to protect the sensitive information of individuals and organizations, prevent hacking and data breaches, and implement security measures to respond to cyberattacks. The program "Emergency Management" focuses on how to respond to emergencies and disasters. Students learn skills and knowledge in establishing emergency response plans, crisis management, and disaster recovery, ensuring that organizations and communities can effectively address safety needs.

In China, various technologies such as the Internet of Things (IoT), artificial intelligence (AI), and biometric recognition are being applied in digital government services to cater to the needs of seniors. These technologies are utilized to establish smart home care centers, smart nursing homes, and smart canteens for seniors in basic service institutions and communities (Yang & Wei, 2013). By implementing home-based care services and leveraging technological advancements, the healthcare, nursing, health, and protection needs of seniors can be effectively addressed. This aligns with providing high-quality government services, as outlined in the "Healthy China 2030" plan. The digitalization of service institutions, communities, and home-based care services for seniors is strengthened through the adoption of IoT, AI, biometric recognition, and other technologies. These technological applications enable older adults to live comfortably, safely, and conveniently. They receive precise medical care and health management, thereby improving their overall well-being and happiness.

16.2.2 Love and Belonging

In the process of setting up and designing the university for the seniors, the sense of belonging and love are two important factors that cannot be ignored. These two factors play vital roles in multiple aspects. Firstly, the university for seniors aims to cultivate a close-knit community. By fostering a strong sense of belonging in the learning environment, the seniors can develop deep friendships and support networks (Jakubec et al., 2019). This sense of community promotes cohesion and stability, allowing the seniors to truly feel like they are part of a larger family. Secondly, the presence of belongingness and love provides essential support for the self-identity and dignity of the seniors. Within the learning environment of universities for seniors, the seniors can showcase their skills and experiences, receiving recognition and respect from others. This sense of identity and dignity is crucial for their mental and emotional well-being, helping them regain confidence and improve their quality of life. Universities for seniors provide a platform for seniors to communicate and interact, offering opportunities to meet and engage with individuals from diverse backgrounds. Through sharing experiences, mutual learning, and support, the seniors overcome feelings of loneliness and social isolation, establishing a robust network of emotional support (Sorkin, 2002). Furthermore, belongingness and love contribute to promoting the psychological well-being and happiness of the senior students. Seniors' universities not only provide opportunities for acquiring knowledge and skills but also ensure the psychological well-being and sense of happiness for seniors. In a caring and affectionate learning environment, seniors can enjoy the pleasure of learning, enhance their sense of happiness, and experience greater life satisfaction.

The Seniors University of China[1] is a nonprofit institution that promotes higher education, research, and cultural preservation, providing older adults with quality learning opportunities. Here, senior individuals can participate in various academic courses, interest classes, and social activities, establish connections with peers of similar age, and develop a sense of community (Yang & Wei, 2013). In the development process, the Seniors University of China has emphasized the establishment of blended learning communities that combine online and offline resources. In offline, collaboration with community educational institutions is prioritized, leading to the creation of community learning sites where diverse learning and social activities are organized. Additionally, universities for seniors encourage senior individuals to engage in volunteer work, providing support and assistance to the community and others. Through volunteer participation, older adults can experience a sense of contribution to society while also forming strong friendships and a sense of belonging with other volunteers. Online platforms have been established, including online learning platforms[2] specifically designed for older adults, as well as WeChat study groups. Through these platforms, older adults can participate in various virtual community activities and engage in discussions with like-minded individuals.

16.2.3 Recognition of Accomplishments and Contributions

Respecting the needs of older adults is of utmost importance in the establishment of universities for seniors. By fostering a strong learning community, seniors can experience care and support from one another, forming deep friendships and support networks that enhance the cohesion and stability of the community (Norris & Barnett, 1994). Elder students long for respect and recognition from others. Having accumulated a lifetime of experiences and knowledge, they desire their contributions to be acknowledged and treated with equal respect by fellow students, teachers, and staff within the university for seniors. This respectful attitude from others can boost their self-esteem and confidence, igniting their enthusiasm to actively engage in learning. Moreover, seniors require opportunities and platforms for self-fulfillment. University for seniors should provide diverse learning opportunities and activities that allow seniors to fully demonstrate their talents and abilities by fostering a learning environment characterized by respect, active listening, and equal opportunities. Universities for seniors enable seniors to unleash their full potential and attain higher levels of self-realization and accomplishment.

The Seniors University of China addresses the needs of seniors by incorporating a blend of online and offline teaching activities. Students have the option to choose between attending offline education for seniors learning centers or participating in online courses. At the end of 2022, there were already 30 branches of the National Open University with provincial seniors open universities or dedicated institutions.

[1] https://lndx.edu.cn/.

[2] https://lndx.edu.cn/publicServicePlatform.

Additionally, over 55,000 grassroots-level education for seniors learning centers have been established, creating a robust support network for the operation of the national university for seniors. By setting up local education for seniors learning centers and provincial seniors' open universities or dedicated institutions, the Seniors University of China provides convenient learning venues and institutions, facilitating offline learning for seniors. This approach fully respects the preferences and needs of older learners, allowing them to select their preferred learning methods. For instance, the Wei Gong Village Campus of the Seniors University of China in Beijing offers experimental and demonstrative offline classes that have attracted numerous individuals in seniors to enroll. The school also organizes supplementary offline tutoring and teaching activities, enabling classmates to gather and exchange their learning experiences. The availability of experimental offline classes within the campus provides an opportunity for seniors who prefer face-to-face communication. Through these classes, students can come together at a fixed location to share their learning experiences, learn from one another, and provide mutual support. This initiative demonstrates the respect and attention given to the learning environment needs of seniors.

Furthermore, the official website of the National Elerly University offers an accessible learning mode specifically designed for older adults. This mode focuses on the individualized needs of older learners, considering their practical circumstances and helping them participate in learning activities more conveniently and independently. By tailoring the learning experience to individual needs and taking into account the realities faced by elders, this accessible learning mode provides them with convenient and self-directed opportunities for learning.

The Seniors University of China strives to meet the diverse needs of seniors by leveraging online information technology and teaching methods, respecting their differences, and creating a more suitable learning environment. The wide range of online courses offered provides seniors with greater options and flexibility. They can engage in online learning based on their interests and schedules, accessing knowledge anytime and anywhere. This flexible teaching approach fully respects the personal choices of seniors, enabling them to participate in learning activities according to their own time and abilities.

Through the integration of online and offline teaching activities, the Seniors University of China demonstrates a genuine respect for the needs of seniors. By providing offline learning centers, a variety of online courses, experimental offline classes, and an accessible learning mode, the university caters to the diverse learning needs of seniors, granting them more autonomy and personalized learning experiences. This approach reflects a deep respect for and attention to seniors promoting their active engagement in the learning process.

16.2.4 Self-Actualization

Maslow's hierarchy of needs theory suggests that human needs can be arranged in a certain order, from basic physiological needs to higher-level needs. The need for self-fulfillment refers to the pursuit of personal potential, self-worth, and growth.[3] Universities for seniors have taken comprehensive and meticulous considerations and implementations to meet the self-fulfillment needs of the seniors.

Firstly, in terms of curriculum design, Universities for seniors offer a wide range of learning courses and activities that cover various fields such as arts, crafts, and academic research to meet the personalized needs of the seniors. By providing diverse course options, universities for seniors encourage them to find their unique learning interests and realize their potential. Secondly, in terms of learning methods, universities for seniors advocate for student autonomy and participation. The seniors can freely choose suitable learning courses and activities based on their interests and needs. This autonomous learning approach can stimulate the motivation and enthusiasm of the seniors, enabling them to pursue personal development and self-fulfillment actively. In terms of showcasing learning achievements, universities for seniors emphasize opportunities for exhibition and sharing. By organizing learning achievement display activities, the seniors can showcase their accomplishments, experiences, and knowledge, gaining social recognition and appreciation. Such opportunities not only boost the confidence of seniors but also encourage them to deepen their learning and seek higher levels of self-fulfillment. Universities for seniors focus on meeting the self-fulfillment needs of the seniors throughout their establishment. By providing diverse courses and activities, encouraging student autonomy and participation, offering opportunities for showcasing learning achievements, supporting social practices, and volunteer activities, and advocating cross-generational communication and collaboration, universities for seniors actively create a learning environment conducive to the growth, development, and self-fulfillment of the seniors.

In foreign examples of universities for seniors, such as France's Third Age University, the United Kingdom's Third Age University (U3A), America's Elderly College, and Australia's Third Age University (U3A), the emphasis on self-fulfillment needs aligns with Maslow's hierarchy of needs theory. College for Seniors in the United States is an educational institution for seniors that provides learning opportunities and social activities. Students at College for Seniors can choose from a wide range of courses, like arts, literature, science, and history. They can engage in group discussions and collaborative projects with fellow students, sharing thoughts and experiences. Additionally, the College for Seniors organizes social activities and cultural lectures, providing platforms for communication and interaction. The Third Age University (U3A) in the United Kingdom is another successful educational institution for older adults. Established in 1982, U3A is dedicated to providing tailored

[3] https://www.simplypsychology.org/maslow.html.

learning and social opportunities for seniors.[4] U3A's courses are organized and facilitated by the students themselves. Seniors can develop courses based on their interests and expertise, sharing knowledge and experiences with their peers. This allows for deeper learning and the fulfillment of self-fulfillment needs. U3A also organizes various social and cultural activities, such as art exhibitions, concerts, and outdoor adventures, enabling seniors to expand their social circles, form friendships, and pursue their interests.

In conclusion, these foreign examples of universities for seniors fulfill the self-fulfillment needs to be outlined in Maslow's hierarchy of needs theory by offering diverse learning courses and activities, promoting student autonomy and participation, and providing social and cultural exchange opportunities. These educational models support ongoing learning, knowledge enrichment, and active social engagement for seniors. By actively participating in learning and social activities, seniors can realize their potential and achieve a sense of self-worth. Thus, these foreign cases of universities for seniors serve as comprehensive platforms for learning and personal growth, meeting the self-fulfillment needs to be highlighted in Maslow's hierarchy of needs theory.

To meet the diverse needs of senior citizens, various flexible forms of education for seniors are available globally. In the next section, we will provide specific details regarding universities for seniors, lifelong learning institutions, community centers, continuing education programs, and distance education for seniors.

16.3 Forms of Aging Education

16.3.1 University for Seniors

In recent years, numerous successful universities for senior cases have emerged worldwide, providing older adults with opportunities for lifelong learning and a vibrant lifestyle. These universities foster a positive environment that encourages seniors to continue learning and develop their skills. Learning and understanding the current typical education model for the senior will help us better optimize the existing education model in the design of teaching for the seniors and design a more suitable learning model for them.

One example is the Open University in the United Kingdom, which offers online learning opportunities for older adults, allowing them to pursue degrees from the comfort of their homes. Their courses encompass a wide range of subjects, including arts, sciences, history, and literature. The Open University also provides comprehensive support services to enhance the learning experience for students.

The University of the Third Age (U3A) is a global organization with branches in multiple countries, including Sweden. U3A's mission is to provide free education

[4] https://www.ageaction.ie.

and social opportunities for older adults (Wilson, 2008). Volunteer teachers offer diverse courses in languages, arts, sciences, and other disciplines. Also, workshops and travel events are organized to facilitate social interaction and cultural exchange.

ULB-OSIRIS (Université Libre de Bruxelles) in Belgium provides a diverse range of courses, including arts, literature, and language, catering to the interests of senior learners (Jacob et al., 2023). Similarly, the "Universidade Sénior" (University for Seniors) in Portugal offers educational opportunities for older adults, with courses in languages, arts, history, and sciences. These courses are designed to meet the learning needs and interests of seniors and are taught by qualified instructors.

Another notable example is the "Universidad para Mayores" (University for Seniors) in Spain, which operates in multiple cities across the country. This university offers a wide variety of courses encompassing philosophy, adult psychology, nature and the environment, literature and drama, fundamental issues of rights, and the great discoveries of science. In addition, there are some elective courses including modern languages, informatics, music, and so on.[5] Its primary objective is to inspire older adults to continue learning and promote their personal and social development.

In China, the Ministry of Education officially established the Seniors University of China in 2022. The Seniors University of China was established under the auspices of the Open University of China and has set up six colleges at its Weigongcun campus in Haidian District, Beijing. It offers 44 offline courses. By the end of 2022, the University had established 30 branches as provincial-level seniors open universities or dedicated institutions, and over 55,000 senior's education learning centers at the grassroots level. The Seniors University of China provides resource sharing, teaching guidance, and public services for universities set for seniors at all levels nationwide. It serves as a platform for sharing educational resources and providing public services, playing a demonstrative, leading, and radiating role in the innovative development of senior's education. Currently, more than 8,000 teachers have joined the faculty of the Seniors University of China. With a focus on leisure and entertainment, active health, skill enhancement, and fulfilling dreams in one's silver years, the university offers a diverse range of senior's education services.

16.3.2 Lifelong Learning Institutes

Lifelong Learning Institutes, affiliated with universities or colleges, offer non-credit courses and programs designed specifically for senior citizens. These institutes prioritize personal growth, intellectual stimulation, and social engagement by providing educational opportunities tailored to the needs of older learners.

One notable example is the "Université du Temps Libre" (UTL) in France, which has branches throughout the country. UTL offers a diverse range of courses in literature, arts, history, sciences, and more, catering to the specific interests and needs

[5] http://www.uam.es/.

of local citizens who are seniors. The institution aims to promote social interaction, knowledge acquisition, and personal development through lifelong learning (Li, 2018).

In the United States, the "Osher Lifelong Learning Institutes" (OLLI) operate on multiple campuses nationwide. OLLI offers academic, cultural, and artistic courses designed for adults aged 50 and above, catering to their unique interests and needs. These courses are intended to provide knowledge, foster critical thinking, and offer social and recreational opportunities.

The shared objective of these lifelong learning institutes is to create an environment that supports continuous learning, encourages active engagement in community life, and provides opportunities to meet the learning and socialization needs of older adults (Brady et al., 2013). They strive to cultivate a positive and enriching learning and social environment, allowing learners who are seniors interested, to form connections, and maintain their mental and physical well-being.

16.3.3 Community Centers and Continuing Education Programs

Many community colleges and universities offer continuing education programs specifically tailored to the needs of older adults (Jackson & Laanan, 2011). These programs may include courses in various subjects, vocational training, and enriching personal opportunities. For example, the Learners Program for Seniors at the Community College of Denver in the United States provides affordable courses for older adults, helping them stay connected to the community while gaining new skills and knowledge.

In the United States, the Community College System of America is one of the largest continuing education programs globally. It offers high-quality and relatively affordable education opportunities to a wide range of students. Community colleges in the US provide options such as vocational training, college credit courses, and language programs. Additionally, Australia has several excellent continuing education institutions. For instance, the Sydney Institute of Continuing Education offers a wide range of short-term courses and vocational training programs, covering various fields of knowledge and skills to meet the needs of diverse learners (Zhong, 2021).

In China, community colleges and continuing education programs are mainly concentrated in economically developed cities. For example, the Community College of Beijing is one of the well-known community colleges in China, achieving significant accomplishments in promoting continuing education. They offer a wide range of vocational training courses, including skills training, language training, and cultural and art training. Moreover, they collaborate with businesses to provide students with internship and employment opportunities. The Community College of Shanghai is also important in China. They focus on cultivating students' practical abilities and professional qualities, achieving remarkable results in skill training, college credit courses, and career development. The Community College of Shanghai actively promotes the development of online learning and distance education, providing flexible learning pathways for more students (Yang & Wei, 2013). The Community College of Guangdong Province has a certain influence in the fields of vocational education and continuing education. They offer diverse training programs such as engineering technology, business management, and tourism services. They also collaborate with enterprises to provide practical education through the integration of industry, academia, and research, helping students better integrate into their professional fields.

16.3.4 Distance Education for the Senior

With the COVID-19 pandemic and the advancement of technology, more and more older adults have begun to engage in distance learning. Online learning platforms offer a wide range of courses and programs that can be accessed from anywhere, providing convenience and flexibility for learners who are senior (Liu, 2021; Yang & Wei, 2013). These platforms offer various courses and programs that seniors can access anytime and anywhere. The Table 16.1 lists the learning platforms that offer courses for older adults internationally (Ji, 2019).

This section explores four different forms of senior's education models. By analyzing teaching models for the seniors in different countries and regions, and classifying them based on location, instructional tools, and equipment utilized, we systematically elucidate the existing education of seniors models. Through studying this chapter, designers, and educators can gain a comprehensive understanding of the current education of seniors models. This understanding can further empower them

Table 16.1 Learning platforms support senior's education

Online learning platforms	
Platform	Introduction
Coursera	Coursera is a well-known online learning platform that offers a wide range of courses, including some relevant to senior's education (Young, 2012)
Udemy	Udemy is an online learning marketplace that offers courses in various languages, skills, and interest categories, some of which cater to the needs of seniors (Uliana Cetina et al., 2018)
edX	edX is a nonprofit online learning platform founded by MIT and Harvard University, providing high-quality university courses, some of which are related to senior's education (Chuang & Ho, 2016)
Khan Academy	Khan Academy is a nonprofit online learning platform focused on providing free educational resources, some of which can apply to seniors (Meng et al., 2018
Future Learn	Future Learn is a UK-based online learning platform that partners with universities and educational institutions worldwide, offering a range of courses relevant to senior's education

to design and develop programs tailored to the circumstances of seniors. Furthermore, they can optimize existing education of seniors models to better facilitate the development of the education of seniors. In the subsequent part, we will continue to deeper into the current utilization of new technologies in the education of seniors. With the advancement of new technologies, education in technologically-rich environments has made significant progress in terms of application and implementation. Exploring the utilization of different technologies in the education of seniors will assist designers and educators in better utilizing new tools and methods, thus promoting the optimization of seniors' learning design.

16.4 New Technologies for Seniors' Education

16.4.1 Artificial Intelligence (AI) Technology

AI technology plays a crucial role in education for seniors. AI brings significant contributions to the field by providing personalized learning experiences tailored to the needs and interests of older adults. Intelligent assistive learning systems enable seniors to access customized learning content and study plans, catering to their specific learning requirements. These systems can automatically adjust the learning materials and difficulty levels based on the seniors' progress and comprehension, facilitating better knowledge acquisition and skill development. Additionally, speech recognition and natural language processing technologies assist older adults in language learning and communication. They can utilize voice assistants for English language learning or engage in voice conversations with family and friends. Voice interactive robots also contribute to the mental well-being of older adults, offering companionship and communication while alleviating feelings of loneliness and emotional stress. Furthermore, these robots can monitor seniors' physical conditions in real time and provide appropriate solutions when they fall ill.

Several countries have developed relevant robot products, such as Japan's PARO robot and the United States' ElliQ robot. These AI-powered robots offer companionship, engagement, and support for older adults, enhancing their overall learning and living experiences. PARO is a robotic baby seal designed to provide companionship and therapeutic support to older adults, particularly those with dementia. It is equipped with various tactile and auditory sensors that allow it to respond emotionally to external stimuli during interactions with the seniors. PARO helps alleviate stress and anxiety. The robot has been introduced in dozens of nursing homes and care facilities in Japan (Zhen, 2020). In New York state, the United States, there is a plan to provide AI companion robots called ElliQ to seniors' individuals living alone. ElliQ aims to help seniors feel connected to their loved ones and serves as a friendly presence in their daily lives. ElliQ can perform specific tasks such as booking shared bikes and setting reminders. In emergencies, it can send messages to friends and family. The robot is also capable of making and receiving video calls. ElliQ can initiate conversations and provide personalized suggestions without prompts (Yuan, 2022). In July of this year, the "He Fa Tong Yan" team from Sichuan University developed a smart voice robot called Xiao He, which can speak dialects. Among China's 280 million seniors' individuals, 251 million speak dialects as their daily language. Many existing intelligent products have difficulty recognizing dialects and fail to serve seniors effectively. Therefore, the team designed and developed this robot. Xiao He can accurately recognize 30 Chinese dialects and 5 ethnic minority languages and respond warmly to the senior's conversational needs. Xiao He also features a facial emotion recognition system that quantifies the person's emotional index based on speech, intonation, and facial expressions, enabling effective monitoring of emotional changes. Caregivers can use the emotional reports to develop personalized care plans. The robot has been well received by seniors, and it is believed that future technological advancements will further improve the ability of elders to truly enjoy the benefits of technological development (Zhang, 2023).

16.4.2 Virtual Reality (VR) and Augmented Reality (AR) Technologies

VR and AR technologies have become increasingly prevalent in the education of seniors. Virtual Reality (VR) allows older adults to fully immerse themselves in virtual environments, enabling them to experience virtual travel destinations, engage in virtual sports activities, and interact with virtual characters. By wearing a VR headset, elders can completely immerse themselves in these virtual environments, enjoying various experiences and stimulation that may otherwise be limited due to physical constraints. This immersive experience not only brings fun and excitement but also helps alleviate feelings of loneliness and depression that some older adults may experience. For example, in Japan, Toshima, a therapist, collaborated with the University of Tokyo to offer a VR tourism course for seniors. This course teaches them how to capture and edit 360-degree VR panoramic videos, allowing them to experience the beauty of different places without leaving their homes. This integration of VR technology with seniors' rehabilitation therapy enhances their overall well-being and sense of adventure (Qin, 2019). Similarly, in the United States, the Camario healthcare institution introduced virtual reality travel courses to fulfill the travel dreams of physically restricted and chronically lonely seniors. By donning a VR headset, seniors can choose from a menu of destinations and instantly transport themselves to their desired city with a simple touch. This innovative use of VR technology provides older adults with the opportunity to explore new places and cultures, promoting mental stimulation and social engagement (Kisken, 2022).

AR and VR technologies can also be used for seniors health management. Through AR technology, older adults can use virtual fitness trainers for exercise or virtual reality therapy to relieve pain and anxiety. These technologies provide older adults with more choices and convenience, helping them maintain physical and mental well-being. For example, Jintronix, a digital rehabilitation center in Canada, incorporates virtual reality and gamified elements into rehabilitation training. Users can control virtual reality scenes through wearable devices and touch screens, engaging in rehabilitation training. Using virtual reality technology, patients can feel fully immersed in a realistic training scene, making it easier to engage in the training process. Gamified elements add fun and engagement to the training, making the process more enjoyable. CyberCycle, a technology company focused on the seniors market in the United States, utilizes digital technology to provide rehabilitation training for the seniors. Cyber Cycle's virtual reality rehabilitation training products include bicycles, treadmills, and other equipment. These products are equipped with smart sensors, screens, and headphones. The smart bicycles can automatically adjust resistance and speed, allowing older adults to exercise at an appropriate intensity and achieve better training results. They can immerse themselves in a virtual world while engaging in enjoyable rehabilitation training. For example, older adults can ride a bike in a virtual scenic area or walk in a virtual city. These products use virtual reality technology and smart devices, transforming traditional rehabilitation training into a more entertaining and interactive digital experience, making it easier for older adults to engage in rehabilitation training (Wang, 2023).

16.4.3 Mobile Internet Technology

Mobile internet technology has brought many conveniences to the education of seniors. As of the current situation in the world, the traditional education of seniors is resource-constrained in terms of providing formal academic education and offering courses focused on professional knowledge. Non-formal educational institutions such as the universities of seniors have limited coverage. However, with the development of technology, older adults can utilize mobile devices such as smartphones and tablets for learning anytime and anywhere. Live streaming and remote learning technologies enable older adults to participate in learning through the Internet, providing an important educational opportunity for those who are physically restricted or unable to leave their homes, and allowing a wider range of older adults to access learning opportunities. They can access various learning resources and tools through online learning platforms and applications.

Furthermore, mobile internet technology can also provide online learning communities and study groups, allowing elders to interact and share with other learners, enhancing the interactivity and social aspects of learning. For example, the development of short video platforms such as TikTok has played a significant role in seniors' learning. By browsing high-quality short videos and live content, older adults can acquire knowledge in news, health, anti-fraud measures, and other areas during their leisure time. This helps older adults update their knowledge and keep up with the times. Moreover, short videos help overcome the constraints of time and space in formal learning between seniors, enabling older adults to learn anytime and anywhere. Wu Yushao, Vice Dean and professor at the Fudan University Institute of Aging Research in China, once stated, "Learning is the best way to age in the future. Compared to the 'beds' in nursing homes, the 'seats' at the universities of seniors are a more active, proactive, and cost-effective option for aging." Expanding the supply of education for seniors and helping solve the problem of "high demand, limited seats" at the universities of seniors requires the necessity of marketization and internalization of education. Among them, content forms represented by short videos and live streams could play an important role, becoming new methods and channels to promote the education of seniors. and "learning at any age" (Liu & He, 2022).

Similar to the situation in China, short video platforms and online streaming services abroad are also popular among older adults, and they provide a wide range of educational content to meet their learning needs and interests. For example, the international version of TikTok is highly popular overseas. Additionally, there are platforms like YouTube, Instagram, and Facebook. YouTube is one of the largest video-sharing platforms globally, collecting a vast array of videos that cover history, science, literature, and arts. Older adults can access these platforms to learn new skills, find content they are interested in, and acquire new knowledge. Many educational institutions and organizations also offer short video lectures and courses specifically designed for older learners. The development of foreign short video platforms provides barrier-free participation diversified learning opportunities for elders, and enriched the education of seniors. These platforms have become valuable resources for older adults to acquire knowledge, broaden their horizons, and maintain cognitive vitality in an ever-changing world.

16.4.4 Challenge of New Technologies for the Senior

The application of these new technologies in the education of seniors faces challenges and issues. Firstly, many older adults are unfamiliar with the use of devices and cannot access the internet and use technology devices, thereby limiting their opportunities to use smart devices. To overcome these technological barriers and improve digital literacy, relevant training and support need to be provided to older adults. Additionally, product design needs to consider the characteristics and needs of older adults to enhance their acceptance and usability of new technologies.

Although new technologies provide some opportunities for social interaction, they still have limitations compared to face-to-face communication. Older adults prefer direct communication and interaction with people, and the application of new technologies may not fully replace real-life interpersonal connections. Some older adults need companionship from family members, not just a talking machine. This may lead to differences and conflicts between younger and older generations in terms of concepts. In today's society, cultivating and maintaining a healthy relationship between older adults and the younger generation is crucial. New technologies can serve as a bridge, allowing older adults to get closer to the younger generation by using new technologies, and the younger generation can also teach older adults to use new technologies to improve their connection with their elders. Therefore, while applying new technologies, it is still important to value face-to-face communication and social interaction among older adults, as well as focus on genuine care and companionship from family members for older adults.

In general, the application of new technologies in the education of seniors provides older adults with more learning opportunities and convenience. Artificial intelligence technology can personalize learning content and plans, while also providing companionship and communication. Virtual reality technology offers immersive learning experiences, helping seniors enjoy more fun, alleviate loneliness, and manage their health. Mobile internet technology enables older adults to learn anytime and anywhere, allowing more individuals to access educational opportunities. The application of new technologies also requires overcoming challenges and issues. We need efforts from all sides to better leverage the role of new technologies in the education of seniors. and meet the continuing education needs of older adults. Countries around the world are actively exploring the development of new technologies to better cater to the continuing education needs of older adults and address their diverse learning requirements. These technologies provide opportunities for lifelong learning, promote social connections, contribute to social harmony, and enhance the overall well-being of older adults.

16.5 Conclusion

This chapter begins by designing a model of senior needs hierarchy based on Maslow's theory of needs. Building upon this model as a foundation, we further develop a hierarchical model for the education of seniors. Next, focusing on the learning needs within the model, we investigate the four main global models currently implemented in the education of seniors. Finally, we analyze the utilization of new technologies for the education of seniors.

This chapter provides management insights for the education of seniors. Administrators and curriculum design ideas for educators. As global aging continues to intensify, we anticipate the emergence of new models and technologies to support the education of seniors., ultimately enabling seniors to enjoy healthier and happier later years.

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