Design Thinking in the Era of Digital Transformation: A Conceptual Framework of Smart Learning Environment for Teacher Professional Development

Ali Gohar Qazi
Institute of Education, University College London, UK & Institute for Educational Development, The Aga Khan University (AKU-IED), Karachi London, UK
e-mail: ali.gohar.21@ucl.ac.uk

Muhammad Yasir Mustafa
Smart Learning Institute, Beijing Normal University, Beijing, China
e-mail: yasirpaf@gmail.com

Huang Ronghaui
Smart Learning Institute, Beijing Normal University, Beijing, China
e-mail: huangrh@bnu.edu.cn

Michael Agyemang Adarkwah
Smart Learning Institute, Beijing Normal University, Beijing, China
e-mail: adarkwahmichael1@gmail.com

Abstract—In the era of digital transformation, teacher professional development has become an essential part of education. The emergence of new technologies and the changing learning environment have made it necessary to reevaluate the traditional approach to professional development. In this study, we explore the concept of design thinking and its application in the creation of a smart learning environment for teacher professional development. We argue that design thinking offers a unique approach to problem-solving and can help educators develop innovative solutions to the challenges they face. We propose a framework for the design of a smart learning environment based on the principles of design thinking, and we discuss the potential benefits of this approach for teacher professional development.

Keywords—*Educational Technology; Pedagogical innovations; Teacher development; PD; Design*

I. INTRODUCTION

In the era of digital transformation, the field of education has witnessed a significant shift in the way learning takes place. With the advent of technology, traditional teaching methodologies are being reevaluated and new teaching and learning approaches are being developed [1][2]. Among these, design thinking has emerged as a popular problem-solving methodology that is being adopted in various domains, including education [3]. In the context of education, design thinking offers a unique approach to developing innovative solutions to the challenges faced by educators in the digital age [4].

The use of design thinking in education is not new, and there is a growing body of research that highlights the benefits of applying design thinking to various educational contexts [5][6]. However, despite its potential, the use of design thinking in teacher professional development is still a relatively unexplored area [4][7][8]. Teacher professional development plays a crucial role in improving the quality of education and ensuring that teachers are equipped with the necessary skills and knowledge to meet the evolving needs of their students [9][10][11][12]. Therefore, it is essential to explore the potential of design thinking in developing a smart learning environment that can facilitate teacher professional development in the digital age.

The traditional approach to teacher professional development typically involves workshops, seminars, and conferences, which are often a "one-size-fits-all" approach and lack personalization [13]. Moreover, they are often time-bound and cannot be accessed at the teacher's convenience. In contrast, a smart learning environment can provide personalized and flexible learning opportunities that can be accessed anytime and anywhere. It can also promote collaboration and community building among teachers, which can help to foster a culture of continuous learning and improvement [14].

The aim of this research is to explore the potential of design thinking in developing a smart learning environment for teacher professional development in the digital age. The study proposes a framework for a smart learning environment that is based on the principles of personalization, flexibility, collaboration, and innovation. It also discusses the benefits of a smart learning environment for teacher professional development and highlights its potential to promote innovation and experimentation in the classroom. The given below research question guided the researchers to carry out this study.

RQ: How to promote teacher professional development in smart learning environments using design thinking principles?

Overall, this research contributes to the growing body of literature on design thinking in education and highlights the potential of a smart learning environment to support teacher professional development in the digital age. The conducted study provides insights into the application of design thinking principles in developing a smart learning environment and highlights the benefits of such an environment for teachers and their students.

The remainder of the paper is structured as follows. In Section II, the theoretical framework for smart learning environments is presented, which includes an overview of design thinking models and smart learning environment frameworks. Section III describes the methodology used to develop the proposed conceptual framework for a smart learning environment for teacher professional development. This includes a description of the research design, data collection methods, and analysis techniques used. Finally, in Section IV, the proposed conceptual framework for a smart learning environment for teacher professional development is presented, which integrates the principles of design thinking, personalization, flexibility, collaboration, and innovation. The section also includes a discussion of the potential benefits of the framework for teacher professional development in the digital age.

II. THEORETICAL FRAMEWORK

A. Design Thinking

Design thinking is a human-centered problem-solving methodology that emphasizes empathy, ideation, prototyping, and testing. In the context of education, design thinking offers a unique approach to developing innovative solutions to the real-life challenges faced by educators in the digital age. According to [15], design thinking provides a framework for educators to develop personalized and flexible learning opportunities that are tailored to the needs of their students [16].

The use of design thinking In education is not new, and there is a growing body of research that highlights the benefits of applying design thinking to various educational contexts. For example, in a study by [17] the authors explored the use of design thinking in a teacher professional development program. The study found that design thinking helped to promote innovation and experimentation among teachers, leading to improvements in their teaching practices and the quality of education. On the other hand, design thinking models are essential in education because they offer a structured, user-centered approach to problem-solving that can lead to more engaging and effective learning experiences for students, promote innovation and experimentation among educators, and help develop intuitive and user-friendly educational technology products. Prominent design thinking models include the 4D model, 3I model, and the widely-used d.school model. These models provide a structured and human-centered approach to problem-solving, generating innovative solutions that are tailored to the needs and experiences of users.

In the context of a smart learning environment, design thinking can provide a framework for developing personalized and flexible learning opportunities that can be accessed anytime and anywhere. A smart learning environment can incorporate adaptive learning technologies and learning analytics to provide personalized feedback and support for teachers. According to [18], a smart learning environment can facilitate collaboration among teachers, enabling them to share best practices and work together on common challenges. Moreover, the use of a smart learning environment for teacher professional development can help to promote a culture of continuous learning and provide opportunities for teachers to experiment with new teaching methodologies and technologies, resultantly promoting innovation and creativity in the classroom.

Several studies have explored the use of design thinking in teacher professional development. For example, [19][20] applied design thinking principles to the development of a teacher professional development program in Malaysia. The program was designed to promote creativity and innovation in the classroom, and it included elements of collaboration, prototyping, and feedback. The authors found that the program was effective in promoting creativity and innovation among participating teachers. According to [21], a smart learning environment can help to promote self-directed learning and enable teachers to take ownership of their professional development. Similarly, [22] explored the use of design thinking and developed a design thinking curriculum that included hands-on activities, collaboration, and feedback. The authors found that the curriculum was effective in improving teacher'' problem-solving skills and promoting innovation in the classroom.

Other studies have explored the use of smart learning environments in teacher professional development. For example, [23][24][25] developed a smart learning environment that included elements of personalization, flexibility, and collaboration. The environment was designed to support the professional development of mathematics teachers in China. The authors found that the smart learning environment was effective in promoting collaboration and improving teachers' problem-solving skills.

In responding to identifying various elements in SLEs, various SLE frameworks are introduced in the wide body of literature to structure for the development and implementation of effective and engaging learning experiences based on the principles of personalization, flexibility, collaboration, and innovation. For instance, the Smart Learning Ecosystem (SLE) framework, developed by researchers at the University of Illinois, incorporates elements of personalization, adaptability, and collaboration, and utilizes learning analytics to provide feedback and support for teachers. The Personal Learning Environment (PLE) framework emphasizes learner autonomy and control over their learning experiences, using a variety of tools and resources. The Intelligent Tutoring System (ITS) framework incorporates artificial intelligence and machine learning algorithms to provide personalized instruction and feedback to learners, with learning analytics for monitoring progress and teacher support. The Community of Inquiry (COI) framework focuses on collaborative learning, emphasizing social presence, cognitive presence, and teaching presence. These frameworks provide a useful structure for meeting the diverse needs of learners in the digital age.

Thus, from the above literature, we can construe that the use of design thinking in a smart learning environment can provide a unique approach to developing innovative solutions to the challenges faced by educators in the digital age. The use of a smart learning environment for teacher professional development can provide personalized and flexible learning opportunities that are tailored to the needs of individual teachers. It can also promote collaboration and experimentation among teachers, fostering a culture of continuous learning and improvement in the classroom. The proposed framework for a smart learning environment for teacher professional development based on the principles of design thinking, personalization, flexibility, collaboration, and innovation can provide a foundation for the development of innovative solutions in teacher professional development in the digital age.

B. Design Thinking and Smart Learning Environment

Design thinking is a problem-solving approach that has gained popularity in recent years. The approach is characterized by a focus on empathy, creativity, and innovation. Design thinking involves understanding the needs of the user, developing a deep understanding of the problem, and then generating innovative solutions. Design thinking has been successfully applied in many fields, including business, healthcare, and education. Additionally, design thinking can be

applied in the creation of a smart learning environment for teacher professional development.

- The first step in the design thinking process is to understand the needs of the user. In the case of teacher professional development, the user is the teacher. The designer must understand the specific needs of the teacher, including their knowledge, skills, and experience.
- The second step in the design thinking process is to define the problem. In the case of teacher professional development, the problem is to provide a flexible and personalized approach to professional development that is tailored to the specific needs of the teacher.
- The third step in the design thinking process is to generate ideas. In the case of teacher professional development, the designer must generate innovative solutions that meet the needs of the teacher. This could involve the creation of online learning resources, the development of a mentorship program, or the creation of a social learning platform.
- The fourth step in the design thinking process is to create a prototype. In the case of teacher professional development, the designer must create a prototype of the smart learning environment. The prototype can be a simple version of the final product that allows the designer to test and refine the design. This could involve developing a small-scale pilot program to test the effectiveness of the smart learning environment.
- The fifth and final step in the design thinking process is to test and iterate. In the case of teacher professional development, the designer must test the smart learning environment with a group of teachers and iterate based on their feedback. This process allows the designer to refine the design and make improvements based on the needs of the user.

III. METHODOLOGY

The study aims to develop a conceptual framework to explore the relationship between design thinking, smart learning environments, and teacher professional development in the era of digital transformation. To achieve this aim, a comprehensive methodology was employed, which involved a rigorous and systematic literature review [26][27].

The literature review was conducted using the two main scientific databases, Web of Science and Scopus, and other academic databases such as ERIC, ScienceDirect, and SpringerLink. The academic search engine, Google Scholar, was used in locating additional relevant literature. A literature search strategy was employed using the relevant keywords "design thinking," "design-based learning," "learning by design," "smart learning," "smart learning environment," and "teacher professional development." For a study to be included, it had to be in English, full-text, and a journal article and had to be aligned with the objective of this study by focusing on using design practices to build a smart learning milieu to promote teacher professional development.
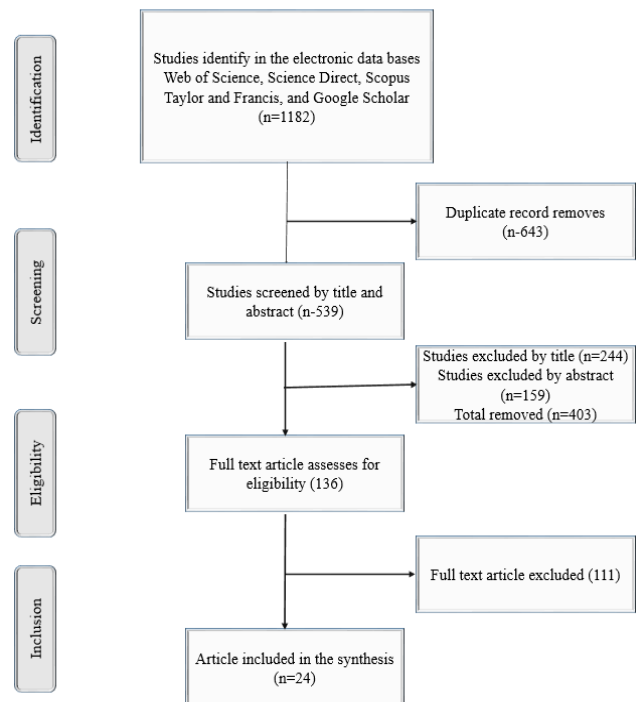

Figure 1. PRISMA Diagram

The inclusion and exclusion criteria were employed to select relevant articles and publications. The 24 research articles were included in the analytic process in accordance with PRISMA [28] the quality of the sources was assessed using established criteria for critical appraisal [29]. This helped to ensure that the literature reviewed was both comprehensive and high-quality..

The literature review focused on exploring key concepts, theories, and best practices related to the use of design thinking and smart learning environments in teacher professional development, as well as the impact of digital transformation on the teaching and learning process. This allowed for a deep understanding of the theoretical background of the study, and provided a solid foundation for the development of the conceptual framework.

A thematic approach was used to analyze the data collected from the literature review, which involved identifying key themes and concepts, and organizing them into a logical framework. This helped to ensure that the conceptual framework was grounded in the relevant literature and accurately reflected the key theoretical concepts and themes related to the research questions.

The limitations of this methodology were carefully considered and addressed. For instance, the potential for bias in the selection and interpretation of the literature was minimized by using established inclusion and exclusion criteria, and by critically appraising the quality of the sources. Additionally, the potential for gaps in the literature was addressed by conducting a comprehensive search across multiple sources and using a variety of search terms.

IV. PROPOSED FRAMEWORK FOR A SMART LEARNING ENVIRONMENT FOR TEACHER PROFESSIONAL DEVELOPMENT

The rapid pace of digital transformation has had a significant impact on education, and teacher professional development has become an essential part of the process. The emergence of new technologies and the changing learning environment have made it necessary to reevaluate the traditional approach to professional development. The traditional approach to professional development has typically involved attending workshops, conferences, and other training sessions. However, in the era of digital transformation, there is a need for a more flexible and personalized approach to professional development. Therefore, based on the principles of design thinking, we propose a framework for the design of a smart learning environment for teacher professional development. The framework is based on four key principles: personalization, flexibility, collaboration, and innovation, as shown in Figure 1.

- o Personalization: The smart learning environment must be tailored to the specific needs of the teacher. This could involve the creation of personalized learning paths, the development of customized learning resources, or the provision of individualized coaching and mentorship.
- o Flexibility: The smart learning environment must be flexible and accessible. This could involve the creation of online learning resources that can be accessed anytime and anywhere, or the provision of virtual coaching and mentorship.
- o Collaboration: The smart learning environment must promote collaboration and community building. This could involve the creation of social learning platforms, the development of peer mentoring programs, or the provision of opportunities for teachers to collaborate on projects and share ideas.
- o Innovation: The smart learning environment must promote innovation and experimentation. This could involve the provision of opportunities for teachers to experiment with new teaching strategies, the development of innovation challenges, or the creation of incubators for new ideas.
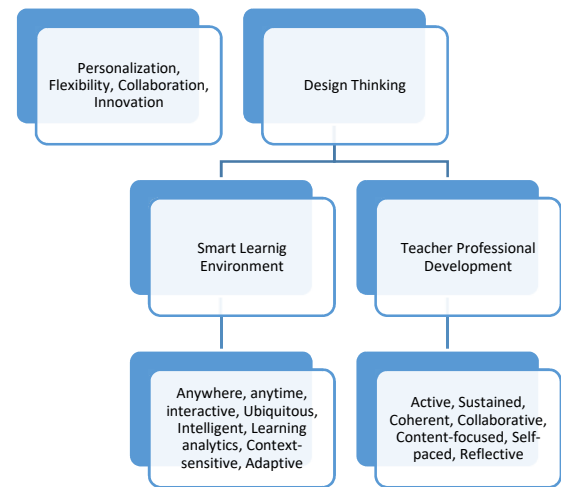

Figure 2. Proposed Conceptual Framework

The proposed conceptual framework illustrates that TPD programs with active and situated learning approaches have shown to be effective in enhancing teacher competencies and skills. Active learning involves hands-on activities, experiential learning, and interactive teaching methods that promote engagement and participation. Situated learning refers to learning that takes place in a real-world context, providing teachers with opportunities to apply their knowledge and skills in authentic situations. Collaborative learning, where teachers work together to share their knowledge and experiences, can also enhance TPD outcomes. Content-focused TPD programs are designed to deepen teachers' knowledge of specific subject areas or instructional strategies, and self-paced TPD programs allow teachers to learn at their own pace, providing flexibility and autonomy. Finally, reflective learning involves self-reflection on teaching practices, which can help teachers identify areas for improvement and enhance their teaching effectiveness. Overall, TPD programs that incorporate these characteristics can be effective in improving teacher competencies and ultimately enhancing student learning outcomes.

On the other hand, relationship between TPD, design thinking, and Smart Learning Environments can be strengthened through the use of technology-mediated TPD platforms. These platforms can provide anytime, anywhere access to interactive, intelligent, and adaptive learning activities that are content-sensitive and personalized to the needs of individual teachers. By incorporating these technologies into TPD, educators can promote a culture of continuous learning and improvement, enabling them to develop innovative solutions to challenges faced in the digital age.

V. CONCLUSION

The era of digital transformation has made it necessary to reevaluate the traditional approach to teacher professional development. Design thinking offers a unique approach to problem-solving that can help educators develop innovative

solutions to the challenges they face. A smart learning environment can provide a flexible and personalized approach to professional development that meets the specific needs of the teacher. By adopting a design thinking approach, educators can create a smart learning environment [30] that promotes collaboration, innovation, and continuous learning and improvement.

REFERENCES

[1] P. Mishra and M. J. Koehler, "Technological pedagogical content knowledge: A framework for teacher knowledge," *Teachers college record,* vol. 108, no. 6, pp. 1017-1054, 2006.

[2] T. Wang, "ICTs and the Education of Design Professionals," in *2009 International Association of Computer Science and Information Technology-Spring Conference*, 2009: IEEE, pp. 126-130.

[3] K. Roth, D. Globocnik, C. Rau, and A. K. Neyer, "Living up to the expectations: The effect of design thinking on project success," *Creativity and Innovation Management,* vol. 29, no. 4, pp. 667-684, 2020.

[4] S. Panke, "Design thinking in education: Perspectives, opportunities and challenges," *Open Education Studies,* vol. 1, no. 1, pp. 281-306, 2019.

[5] L. Kimbell, "Rethinking design thinking: Part I," *Design and culture,* vol. 3, no. 3, pp. 285-306, 2011.

[6] J. Liedtka, "Why design thinking works," *Harvard Business Review,* vol. 96, no. 5, pp. 72-79, 2018.

[7] R. Lor, "Design thinking in education: A critical review of literature," 2017. ACEP ISBN 978-986-5654-50-4

[8] K. Phusavat, A. N. Hidayanto, P. Kess, and J. Kantola, "Integrating Design Thinking into peer-learning community: Impacts on professional development and learning," *Journal of Workplace Learning,* vol. 31, no. 1, pp. 59-74, 2019.

[9] B. Basma and R. Savage, "Teacher professional development and student literacy growth: A systematic review and meta-analysis," *Educational Psychology Review,* vol. 30, no. 2, pp. 457-481, 2018.

[10] L. Darling-Hammond *et al.*, *Empowered educators: How high-performing systems shape teaching quality around the world*. John Wiley & Sons, 2017.

[11] L. Darling-Hammond, "Teacher learning that supports student learning," *Educational Leadership,* vol. 55, no. 5, pp. 6-11, 1998.

[12] A. G. Qazi and F. J. Mtenzi, "The Conceptual Framing, Design, and Development of Mobile-Mediated Professional Development for Primary Mathematics Teachers," *International Journal of Mobile and Blended Learning (IJMBL),* vol. 15, no. 2, pp. 1-19, 2023.

[13] H. K. Bett, "The cascade model of teachers' continuing professional development in Kenya: A time for change?," *Cogent Education,* vol. 3, no. 1, p. 1139439, 2016.

[14] A. Gohar, "Designing an Innovative Mobile-Enabled Continuous Professional Development Solution for Teachers," *EDULEARN22 Proceedings,* pp. 6862-6867, 2022, doi: 10.21125/edulearn.2022.1613.

[15] J. S. Gero and J. Milovanovic, "A framework for studying design thinking through measuring designers' minds, bodies and brains," *Design Science,* vol. 6, p. e19, 2020.

[16] M. G. Luchs, "A brief introduction to design thinking," *Design thinking: New product development essentials from the PDMA,* pp. 1-12, 2015.

[17] S. Lee, T. Kim, J. Kim, S. Kang, and J. Yoon, "The effect of a design thinking-based maker education program on the creative problem solving ability of elementary school students," *Journal of The Korean Association of Information Education,* vol. 23, no. 1, pp. 73-84, 2019.

[18] P. A. García-Tudela, P. Prendes-Espinosa, and I. M. Solano-Fernández, "Smart learning environments: a basic research towards the definition of a practical model," *Smart Learning Environments,* vol. 8, no. 1, pp. 1-21, 2021.

[19] C.-M. Yang, "Applying Design Thinking as a Method for Teaching Packaging Design," *Journal of Education and Learning,* vol. 7, no. 5, pp. 52-61, 2018.

[20] R. Wahab, A. Abdullah, M. Abu, N. Atan, M. Mokhtar, and M. Hamzah, "A learning 3D geometry through sketchup make (SPPD-SUM) to enhance visual spatial skills and the level of geometric thinking," *Journal of Fundamental and Applied Sciences,* vol. 10, no. 6S, pp. 1005-1039, 2018.

[21] G.-J. Hwang and Q.-K. Fu, "Advancement and research trends of smart learning environments in the mobile era," *International Journal of Mobile Learning and Organisation,* vol. 14, no. 1, pp. 114-129, 2020.

[22] T. M. Kessner *et al.*, "(Design) thinking out loud: adolescents' design talk in a library makerspace tabletop game design camp," *Information and Learning Sciences,* vol. 122, no. 9/10, pp. 651-670, 2021.

[23] S. K. Cheung and F. L. Wang, "The continuous pursuit of smart learning," *Australasian Journal of Educational Technology,* vol. 37, no. 2, pp. 1-6, 2021.

[24] B. Gao, Q. Wan, T. Chang, and R. Huang, "A framework of learning activity design for flow experience in smart learning environment," in *Foundations and Trends in Smart Learning: Proceedings of 2019 International Conference on Smart Learning Environments*, 2019: Springer, pp. 5-14.

[25] Y. Rosmansyah, B. L. Putro, A. Putri, N. B. Utomo, and Suhardi, "A simple model of smart learning environment," *Interactive Learning Environments,* pp. 1-22, 2022.

[26] Y. Xiao and M. Watson, "Guidance on conducting a systematic literature review," *Journal of planning education and research,* vol. 39, no. 1, pp. 93-112, 2019.

[27] A. K. Akobeng, "Understanding systematic reviews and meta-analysis," *Archives of disease in childhood,* vol. 90, no. 8, pp. 845-848, 2005.

[28] D. Moher *et al.*, "Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement." *Systematic reviews, vol. 4, no. 1, pp. 1-9, 2015.* https://doi.org/10.1186/2046-4053-4-1

[29] H. Arksey and L. O'Malley "Scoping studies: towards a methodological framework." *International journal of social research methodology*, vol. 8, no. 1, pp. 19-32, 2005.

[30] R. Huang, M. Y. Mustafa, A. Tlili, R. Zhuang, T. Chang, and D. Burgos, "Design of Online-Merge-Offline (OMO) learning environments in the post-COVID-19 era: case study analysis," in *International Encyclopedia of Education (Fourth Edition)*, R. J. Tierney, F. Rizvi, and K. Ercikan Eds. Oxford: Elsevier, 2023, pp. 296-304.