Advancing an Integrative AI-assisted Adaptive Learning Environment for Teacher Education: Case of the BRICS Countries

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Abstract
Integrating artificial intelligence (AI) into teacher professional development (PD) is a promising way to enhance teaching practices and foster innovation in education. However, the development and adoption of AI-based educational platforms face unique challenges in the BRICS region, including technological infrastructure and cultural diversity. This study aimed to identify key aspects of teaching in developing an integrative AI-assisted adaptive learning environment (ALE) in the region. Theoretical methods were used along with qualitative analyses of in-depth interviews and focus group discussions of 36 professors, researchers, and experts from Iranian universities. The findings of this study provided perspectives on the feasibility and effectiveness of developing a joint AI-ALE platform, emphasizing the importance of contextualizing AI initiatives and educational approaches to the needs and constraints of each country and underscoring the significance of local training programs, understanding areas of growth, clarifying values and cultures to be shared with other parties, designing educational resources compatible with collaborative platforms, and overcoming technological barriers. The study provided recommendations on capacity building and joint partnerships for educational innovation, and the development of AI-based teaching practices to open up new opportunities for PD of the next generation of educators for the digital landscape in the BRICS area.
Keywords: adaptive learning environment, AI Integration, teacher education, teacher professional development.

Развитие интегративной адаптивной среды обучения с использованием искусственного интеллекта для подготовки учителей в странах БРИКС

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Аннотация
Интеграция искусственного интеллекта (ИИ) в профессиональное развитие учителей (ПД) является многообещающим способом улучшения практики преподавания и содействия ин-

новациям в образовании. Однако разработка и внедрение образовательных платформ на основе ИИ сталкиваются в регионе БРИКС с проблемами, связанными с технологической инфраструктурой и культурным разнообразием. Целью данного исследования было выявление ключевых аспектов преподавания в интегративной адаптивной среде обучения (АСО) с использованием ИИ. Теоретические методы использовались в совокупности с качественным анализом интервью и обсуждений в фокус-группах 36 профессоров, исследователей и экспертов иранских университетов. Результаты данного исследования демонстрируют перспективы реализации совместной платформы ИИ-АСО и ее эффективность: доказана важность контекстуализации ИИ и образовательных подходов к потребностям и ограничениям каждой страны; показана значимость местных программ обучения, национального понимания областей роста, определения ценностей и культурных особенностей, которыми следует поделиться с другими сторонами; выявлены пути разработки образовательных ресурсов, совместимых с общими платформами, с целью преодоления технологических барьеров. Исследование содержит рекомендации по наращиванию потенциала сотрудничества в целях образовательных инноваций, по разработке на основе искусственного интеллекта методов обучения, которые откроют новые возможности для профессионального развития следующего поколения педагогов в цифровом пространстве региона БРИКС.
Ключевые слова: адаптивная среда обучения, ИИ интеграция, педагогическое образование, профессиональное развитие педагогов.

Introduction

AI has proven to be a transformative force in accelerating some sectors, including education. The development of AI has led to improvements and innovations that have impacted human life, with education being an essential component of social and individual development. One of the main effects of this technology is improving educational accessibility and acceptability, which has a significant impact on educational structures and schools. AI transformations not only bring about changes in economic, cultural, social, and technological aspects but also improve the quality of life and general conditions of citizens through the promotion of education, which prepares professionals with a high level of expertise and skills necessary to work in a dynamic digital environment (Kabudi et al., 2021; Wollny et al., 2021).

The BRICS-2025 economic cooperation strategy has introduced digital transformation as one of the most important areas of cooperation between countries. The BRICS countries have made significant gains in bridging the digital divide and developing digital skills (Pletyago & Antonova, 2023). Deepening cooperation and leveraging the collective experiences of these countries creates an innovative synergy for the sustainable development of important sectors, including education through digital technologies. Focusing on education, AI is considered an effective tool in smart education that affects adaptive-personalized learning experiences, smart administrative systems, and automated assessment and collaboration (Kabudi et al., 2021; Kamalov et al., 2023; Wollny et al., 2021). The use of AI technologies in education results in an adaptive learning environment that intelligently customizes content, resources, and learning activities to fit the unique preferences and needs of each student. By analyzing student data, these systems make intelligent decisions to provide personalized learning experiences, optimize learning outcomes, and enhance student engagement (Gligorea et al., 2023). This integrative approach in teacher education improves to a new level of capacity building and supporting educational goals tailored to students' needs.

The development of an Integrative AI-assisted Adaptive Learning Environment (IA^2LE) is of great importance for the professional training of teachers since it provides facilities that help teachers improve their professional competencies and provide more engaging learning environments for students. Such environments are equipped with data collection tools, data analytics libraries, personnel adjustments, and educational optimization opportunities that lead to improved quality of teaching and learning.

Second, an IA²LE enables teachers to develop the technical and technological skills needed to teach in today's digital world. Using AI technologies and advanced digital tools such as learning management systems, content creation tools, and collaboration platforms, teachers can provide diverse and dynamic learning experiences for students. Third, an IA²LE allows teachers to easily respond to the changing needs of students and the learning environment. These tools use custom settings, adaptive learning algorithms, prompt-effective feedback mechanisms, and advanced learning resources to help teachers deliver effective and flexible instruction.

In summary, the development of an IA²LE for teacher training as a powerful tool for improving the quality of education and promoting technical and advanced skills can play a determinant role in digital education. This study tried to suggest a development model of an IA²LE to facilitate professional development (PD) among the BRICS countries.

Literature review

Integrating AI into educational systems transforms the way students learn, teachers train, and institutions function. AI algorithms can also transform the educational landscape, bridge gaps, and provide a more effective, engaging, and inclusive learning environment. The concept of adaptive learning is based on the fact that students have different backgrounds, learning preferences, and cognitive abilities (Gligorea et al., 2023). Older learning platforms often offer the same content and activities to all students, regardless of their unique characteristics and needs. This approach may lead to frustrating learning experiences, as some students may find the content too difficult or too easy, leading to a lack of engagement or limited progress (Gligorea et al., 2023). Intelligent personalized learning, where instruction is adapted to each student's specific learning needs and preferences, makes it possible to match learning needs and gain individual learning experiences using adaptive learning algorithms (Kamalov et al., 2023). Personalized learning platforms called "adaptive learning systems" (ALSs) can be used to deliver lessons that are adapted to students' learning styles and preferences, as well as the order and difficulty level of tasks (Gligorea et al., 2023; Wang et al., 2020). Adaptive learning promotes self-paced learning, provides targeted support, and provides a more effective and engaging learning environment (Pliakos et al., 2019). Integrated with AI data mining techniques, such learning systems allow for continuous improvement by identifying strengths and weaknesses, and generating personalized recommendations and interventions which is known as learning analytics (LA) (Chen et al., 2020; de Sousa et al., 2021).

AI in education emerges from the combination of the fields of computer science, statistics, and education. In addition to these three areas, AIEd is an interdisciplinary field that also includes cognitive psychology and neuroscience. Among them, the importance of educational data mining, learning analytics (LA), PD, and computer-based education is highlighted (Chen et al., 2020; de Sousa et al., 2021; Kamalov et al., 2023). LA is defined as a systematic process that measures, collects, analyzes, and finally reports information about the learning process and its environments. The main goal of this process is a deeper understanding of the learning process and its optimization, as well as to improve educational environments (Chen et al., 2020). Using AI technologies, learning analytics examines statistics, visualization, discourse analysis, and social networks, and tries to identify patterns, relationships, and differences in learning data (Romero & Ventura, 2013). These technologies can automatically identify important relationships and features in learning data and analyze information more accurately and efficiently by relying on clustering data mining algorithms. In addition, by using AI algorithms, it is possible to automatically recognize learning patterns and optimize educational processes in diverse

educational environments. As a result, AI technology has an important function as a key tool in improving and optimizing LA, helping teachers' PD, and improving the quality of teaching and learning (Chen et al., 2020).

Moreover, teachers' PD is defined as the process of improving and upgrading the skills, knowledge, and abilities of teachers in various educational fields, which today is influenced by AI technology (Kuhl et al., 2019; Tammets & Ley, 2023). This process includes training teachers about the optimal use of digital tools and resources, the ability to analyze educational data using AI algorithms and methods, improving communication skills, and interacting with students through AI-based technologies. In addition, teachers' PD includes the education and training of concepts related to professional ethics in the use of advanced technologies, so that teachers can improve their productivity and effectiveness in the educational environment with responsibility and commitment and successfully meet the needs and challenges of education in the modern world.

The concept of teachers' PD in an adaptive learning environment through AI is inspired by the idea that each teacher has unique needs, abilities, and learning styles. Due to this diversity, a uniform approach to teacher training may not be able to meet the diverse needs of all teachers. However, the integration of AI in the teacher training process provides new possibilities (Jing et al., 2023). In the meantime, with the help of machine learning algorithms, adaptive learning systems can prepare and present educational content and activities in a personalized way that aligns with teachers' needs and preferences by analyzing their data. This not only increases the quality and efficiency of teachers' training but also enhances their motivation and satisfaction with the learning process (Gligorea et al., 2023; Green & Donovan, 2018; Pliakos et al., 2019). Therefore, PD in an AI-assisted environment can facilitate recognizing the strengths and weaknesses of each user and adjust teaching plans accordingly, and in this way, improve their knowledge and competencies, and the quality of teaching (Gligorea et al., 2023; Green & Donovan, 2018; Pliakos et al., 2019).

As the adoption of AI-enabled learning environments for teacher education expands, it is even more important to understand how these environments can help improve teachers' knowledge and abilities. One of the strengths of these environments is that by carefully analyzing each teacher's data, they can offer a personalized learning path that is built based on their needs and preferences. This personalized path can help teachers improve and expand their knowledge more effectively in the subjects that need reinforcement (Gligorea et al., 2023; Green & Donovan, 2018; Pliakos et al., 2019). Also, since these environments can dynamically react to each teacher's performance and progress, teachers can use continuous feedback to improve the quality of their teaching and learning (Gligorea et al., 2023; Tapalova & Zhiyenbayeva, 2022; Wang et al., 2020). For example, if teachers need reinforcement in a certain area, the system can provide them with training resources and exercises that fit their needs, and then provide feedback on their performance and progress. This process helps teachers to continuously improve and acquire new knowledge and skills (Wang et al., 2020). As a result, learning environments compatible with AI can significantly improve the knowledge and abilities of teachers and, the quality of teaching and learning in schools and educational institutions.

The Integrative Feature of an AI-assisted ALE for Teachers

In the study of the integrative feature of an AI-assisted ALE, its effect on the knowledge axis can be mentioned. One of the updated models for conceptualizing the knowledge needed by teachers is the TPACK model, which is inspired by the original Schulmans' PCK model (1986). In revision, Graham (2011) pointed to three fundamental axes of TPACK, namely technological knowledge (i.e. computer, video, images, etc.),

pedagogical knowledge (i.e. teaching philosophy, methods, individual differences, learning styles, etc.), and content knowledge (i.e. science, geography, math, etc.). Graham emphasized that, in PD, a teacher needs to cultivate all three dimensions of knowledge, since the integration of content knowledge with the knowledge of related pedagogical issues is the necessity of teaching and their integration with technological knowledge is the prerequisite of today's teaching (Benson & Ward 2013; Çam & Erdamar Koç, 2021; Koehler & Mishra, 2008; Schmidt et al. 2008; Graham 2011). In short, the knowledge needed by teachers can be defined as follows:

– Pedagogical knowledge focuses on knowing and understanding the principles and methods of teaching and learning, including educational strategies, assessment techniques, classroom management, and understanding educational needs and styles. Teachers who are armed with strong pedagogical knowledge are highly capable of recognizing students' needs, designing effective learning experiences, and providing a supportive and inclusive learning environment.

– Technological knowledge refers to the understanding of how to effectively use technology tools and resources, and the skills and competencies necessary to improve the learning process, including how to use learning management systems, digital content creation tools, educational programs, and platforms. Teachers with strong technological knowledge are capable of seamlessly integrating technology into teaching and enhancing active learning.

– Content knowledge refers to the knowledge related to the subject area being taught, for example, the content knowledge of a language teacher includes a deep understanding of the concepts and principles of language teaching, theories and application of language skills, etc. Backed by strong content knowledge, such teachers can develop complex ideas, design and deliver structured learning, and make connections between concepts.

Therefore, the existence of the three types of pedagogical, technological, and content knowledge is essential for teachers, and their combination helps teachers become experts in their field and create dynamic and engaging learning experiences. By analyzing classroom data, AI provides more effective teaching methods and appropriate teaching materials, and by recognizing student behavior patterns, it helps teachers communicate better (Celik et al., 2022; Celik, 2022; Khosravi et al., 2022). This real-time feedback makes it possible to improve the teaching process and connect more closely with students, creating an intelligent learning environment.

In the BRICS-2024 region (Brazil, Russia, India, China, South Africa, Egypt, Ethiopia, Iran, and the United Arab Emirates), such AI-assisted learning environments can play a very significant role in developing common educational standards, training skilled teachers, and improving the quality of education. Considering the cultural and social diversity in these countries, the use of AI technologies can be applied in different ways to suit local needs and conditions. Additionally, these approaches can help improve access to education for more disadvantaged communities and expand educational opportunities. Also, by improving the knowledge and abilities of teachers in using technology and new educational experiences, it is possible to help improve the quality of teaching and learning of students in these countries. As a result, such learning environments, adapted to the specific needs and challenges of each BRICS member, can not only help improve educational systems and cultural and social progress in these countries but also integrate adaptive techniques and technologies into learning platforms and courses. Besides, these platforms use algorithms and AI to analyze student data, including their interactions with the platform, assessment results, and progress. Among the advantages of learning systems compatible with AI, one can mention creating a better learning environment, flexibility in time planning, providing immediate feedback, flexibility in controlling students' learning

experiences, and accelerating students' development. Also, the role of AI and machine learning in collecting and analyzing student data to provide personalized learning experiences is critical (Gligorea et al., 2023; Jing et al., 2023; Tapalova & Zhiyenbayeva, 2022; Wang et al., 2020).

The problem of the present research was to specify the PD aspects in the digital age to fill the gap between the existing educational conditions and the ideal and dynamic states empowered by AI potentials and the practical realities of implementing such technologies in the BRICS countries. While AI promises a revolution in educational practices, the constrained infrastructure or the imposed political directions cause obstacles to its effective integration into teacher training. The purpose of this study was to identify the most influential factors affecting teachers' PD to provide a comprehensive model of advancing an IA^{2}LE in the BRICS bloc, by identifying and balancing traditional education and considering cultural values and ethics with modern technological resources. This purpose also specified how the integrative nature of such a learning environment affects the PD of teachers and ultimately what advantages and difficulties its development faces. By addressing such objectives, this study seeks to identify the most fundamental aspects of developing collaborative professional platforms and providing insights and practical recommendations for educators, policymakers, and stakeholders in these countries. Given this backdrop, this study seeks to address the following research questions:

RQ1. How does the integrative element of an IA^{2}LE affect teacher development?

RQ2. What are the main steps to be considered in developing an IA^{2}LE for teachers?

Methodology

Participants

The education sector in Iran is divided into two main parts namely basic education (i.e. preschool, primary and secondary school), and higher education (i.e. university) which does not include professional training or short-time courses. In Iran, there are 16.5 million basic students (including more than 16 million Iranian and 500 thousand non-Iranian; 8.5 million girls and 8.9 million boys; and 100 thousand exceptional students) and 3.5 million university students (including more than 3.3 million Iranian and 60 thousand non-Iranian; 1.6 million women and 1.7 million men; and 25 thousand disabled students) (Presidency of the I.R.I Plan and Budget Organization, 2023; Ministry of Science, Research, and Technology, 2023). The number of teachers in basic education is 900 thousand while this number is more than 88 thousand in higher education. Although efforts have always been made to provide fully-trained teachers to teach this population, the education system has faced challenges in responding to the needs of the day. In this research, 36 university professors, researchers, and experts were asked to participate whose characteristics are presented in Table 1.

Table 1. *Demographic Characteristics of the Participants*

	Category	*N*
Gender	Female	19
	Male	17
Age	29-33	13
	34-38	15
	39-43	8
Educational background	PhD in computer science	7
	PhD in education/ELT	16

	PhD in IT	9
	Master's in education/ELT	4
Work Experience (years)	5-9	18
	10-14	12
	15<	6
Current position	Faculty member	24
	Research scholar in education	8
	Data scientist	4
Total		36

Instrumentation

The interview protocol designed in this study included seven open-ended questions to examine the views of the participants about the theoretical-practical foundations, methods, and effects of designing and applying an IA²LE among BRICS members. Also, follow-up questions were asked to better understand the opinions, experiences, and views of the participants regarding current national directions and actions. At the beginning of the process, ethical considerations and confidentiality of the participants were ensured.

Design

Theoretical methods (recognition and examination of variables based on previous philosophical, educational, psychological, and occupational literature), along with qualitative analysis of in-depth interviews and focused group discussions with university professors, researchers, and experts were used.

Procedure

After studying the previous literature and the findings of other researchers, interviews with the participants were coordinated. To comply with the ethical guidelines for conducting interviews, the processes and objectives of the study were introduced to the participants and they were assured of the confidentiality and anonymity of their answers. After obtaining their informed consent, interviews were conducted within a time frame of 30 to 35 minutes, and three one-hour discussion sessions were held online, after which responses were immediately converted and categorized.

Data analysis

The interviews were transcribed and then the open, central, and selective coding techniques were performed using MaxQDA. This way, convergent and frequent topics were sorted and classified, category labels were defined, central categories were integrated, and the main components were identified. Finally, to ensure the presented categories and model, the model was discussed and evaluated by participants as well.

Results

To find out how an integrative element of an IA²LE affects teacher development (RQ1), the results of data analysis were categorized into two separate sets. Figure 1 summarizes the main findings of the study.

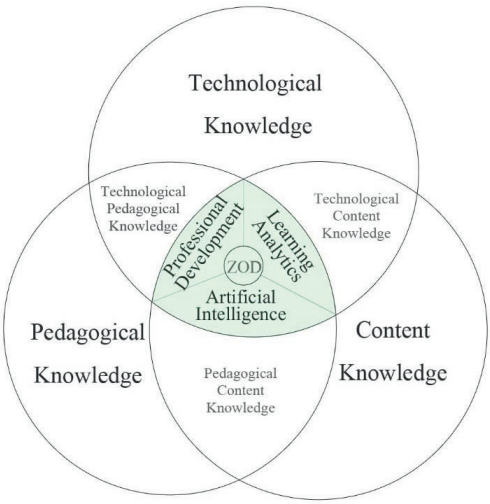

Figure 1. *The conceptual model of the integrative feature of an IA²LE in teacher education*

This Venn diagram can demonstrate how technological, pedagogical, and content knowledge are combined, as well as how they relate to PD, AI, and LA. In the center of the diagram, the triple meeting point of PD, AI, and LA is the Zone of Optimal Development (ZOD) for teachers to significantly improve their teaching effectiveness, skills, and knowledge. In this figure, technological knowledge (including the use of tools, platforms, and modern technologies in teaching and learning processes, e.g. facilities such as cloud computing, augmented reality, and the Internet of Things), pedagogical knowledge (including techniques, methodologies, and educational theories, from including traditional and modern approaches in education), and content knowledge (including pedagogical content, educational resources, and lesson content in different fields) are influenced by the three axes of PD, AI, and LA. Here, PD refers to the improvement of people's skills, knowledge, and abilities, implemented in educational and practical settings. AI in the field of education helps both teachers and managers make decisions, allocate resources, provide personalized content, and improve educational and learning processes. LA also provides valuable information that is used in improving educational processes and enhancing the quality of learning by using the analysis of educational and learning data. Therefore, the elements of PD, AI, and LA have profound effects on teachers' technological knowledge, pedagogical knowledge, and content knowledge and collectively improve teaching and learning processes, including better educational experience, enhancing individual capabilities, and increasing the quality of education.

In identifying and determining the main steps in advancing an IA²LE for teachers (answer to RQ2), various components were examined. The results of data analysis related to the stages of development and application of an IA²LE were displayed in the form of a 6-stage cycle (Figure 2).

The proposed framework includes the following steps:

1. Identification: By identifying the stakeholders and groups that have the most influence on the implementation of the project, an analysis of the main needs and problems is carried out to find the most suitable solutions and to better understand the subject and the problem in question.

2. Planning: A comprehensive program is designed according to the needs and objectives (both at the local and BRICS levels), which includes curriculum design,

financial and human resource planning, and educational design to provide appropriate educational content and activities.

3. Development: Educational contents are produced comprehensively and diversely, different technologies are integrated to implement the training, and prototypes of the system are developed to apply the necessary improvements and changes.

4. Review and approval: First, mutual reviews are done by various experts and groups to evaluate the quality of the project. Once the project passes the quality evaluation, it proceeds to the implementation phase which includes training, support, and prototype testing.

5. Publication: The learning system and educational data are published to provide public access, and the data needed to conduct further research and studies are collected.

6. Analysis and improvement: The data relating to the users, the performance, and the effectiveness of the project are analyzed, then according to the results, the future periods of the project and future planning are looked at.

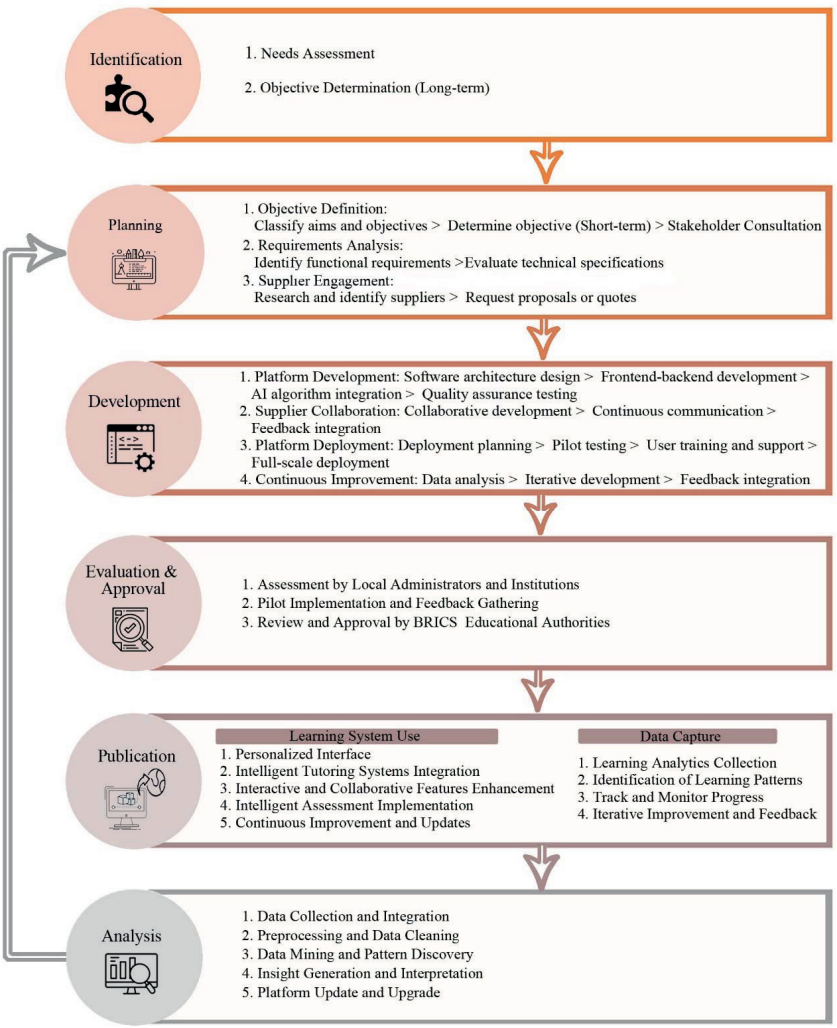

Figure 2. *Proposed IA²LE development framework*

Discussion

In this study, an attempt was made to identify the most significant aspects of using an IA²LE for teacher PD. In this regard, it was tried to understand how such an environment affects PD, identify the influencing factors and how they integrate, and present a comprehensive model of the development of an IA²LE in the BRICS group.

In the proposed model of Figure 1, the components mentioned by the participants were classified into two levels. At the external level, the same components of TPACK can be observed which were supported in previous studies (e.g. Chen et al., 2020; Romero & Ventura, 2013; Koehler & Mishra, 2008; Çam & Erdamar Koç, 2021; Graham, 2011; Benson & Ward, 2013; Nawaz et al., 2011). Meanwhile, at the internal level, there exists a triplet of PD, AI, and LA, with the ZPD located at their intersection. The external circle of knowledge refers to the axes of technological knowledge and modern tools in teaching and learning, pedagogical knowledge and different approaches to education, and content knowledge and educational resources, which are affected by the central triangle of PD and the improvement of individual's skills and knowledge, AI use in making decisions and managing the pedagogical processes, and LA in mining educational data to improve teaching-learning. This issue is supported by de Sousa et al. (2021), Khosravi et al. (2022), and Tammets and Ley (2023), in the sense that in their studies it was shown that the use of AI in education plays an important role in improving the efficiency and effectiveness of educational processes and in this way significantly improves the learning experience of students. Also, the use of AI can intelligently accelerate the analysis of educational data, identify learning patterns, rely on educational personalization, and thus help make better decisions and more effective orientation.

Although these two levels appear different on the surface, there are multidirectional connections between them that show their importance in facing the modern challenges of education and PD. For instance, technological knowledge, as a determinant factor in today's education, includes tools, systems, methods, and strategies used to improve educational processes and learning quality. Also, AI, as one of the key drivers of innovation in science and technology, plays an important role in improving teaching and learning processes as well (e.g. from analyzing educational data to delivering customized content, AI is constantly changing and improving teaching and learning methods which also bolsters content knowledge). Along with these two, pedagogical knowledge plays an important role in teachers' PD and empowerment which consequently affects the quality of teaching and learning. Therefore, the internal level elements can improve and enhance teaching and learning processes by combining technological knowledge, pedagogical knowledge, and content knowledge. Therefore, the Venn diagram (in Figure 1) not only shows the integration of the extracted concepts, but also explicates the connections in the model to gain insights into improving educational systems and PD.

Relying on the power of AI, such an environment can fully integrate technological, pedagogical, and content knowledge. This integration is made possible through advanced AI algorithms that automatically analyze data and identify connections between various concepts. Then, by leveraging deep learning methods, the platform can provide the most accurate and best content and tutorials to each user, considering their knowledge level, interests, and needs. This way, the AI in this platform, along with LA data and PD objectives ensure that all dimensions of knowledge are harmoniously and fully integrated and presented, taking advantage of the latest scientific and technological advances. Finally, the concept of ZOD, at the intersection of PD, LA, and AI, refers to the optimal effect of the interaction of the components. This way, PD, which is related to improving the skills, knowledge, and abilities of people in their work, can be facilitated through AI by analyzing educational data and providing personalized solutions, identifying learning

patterns, and suggesting possible and necessary improvements in educational processes (Nazaretsky et al., 2022).

The findings of the second RQ represented that such an environment operates according to a comprehensive management cycle. The proposed framework includes various steps that may also help future socio-cultural programs in the BRICS group. In the identification stage, first, the needs will be carefully identified and then considered by the analysis of policymakers so that the most appropriate path for development and progress can be determined. In the planning stage, with detailed curriculum design and technical planning, it provides the possibility of more efficient and effective implementation, as well as, attracting and active participation of suppliers and choosing effective sources. The development phase charts the way to deliver an efficient and quality platform by generating and improving content, integrating technology, reviewing and validating processes, and ensuring the optimization process. Finally, by publishing and collecting data, the learning system is evaluated and this information is used for knowledge sharing and future improvements. In the reflection and analysis stage, users' data are examined and by analyzing users (i.e. teachers) and system performance, effect evaluation and future planning are done to make the necessary improvements and achieve sustainable development. This framework also follows the triple of Planning-Development-Use by Nawaz et al. (2011).

In the development of this environment, AI is used to integrate and improve the processes of identifying needs, analyzing data, and continuous improvement, which leads to providing better and more targeted training to users. From a broader perspective, in the BRICS countries, this platform can help improve educational content and provide a more effective learning experience. Also, using AI technologies can help ameliorate access to education for people in areas with geographical and/or resource limitations to benefit from educational facilities. At each stage of the framework, the role and importance of the BRICS countries is clearly defined. Economically, culturally, and technologically, these countries can provide useful models and experiences that may be used in the development of a common educational and learning framework. For example, in the identification phase, the analysis of needs and possible problems in the countries can serve as an important reference for identifying needs and obstacles in other countries. In the planning phase, successful models and strategies used in the countries can be considered useful models for planning and implementing future programs. In general, the experiences and knowledge obtained from the BRICS countries in each of the stages can be considered a valuable resource for increasing the efficiency and quality of the process.

Conclusion

Based on previous literature and the findings of this study, the challenges, opportunities, and best practices for advancing an IA^{2}LE in teacher training were discussed. This study has some theoretical implications that are mentioned below. This research leads to a better understanding of the effects of learning environments compatible with AI on the PD of teachers. Furthermore, by providing a comprehensive model for the development of an AI-friendly learning environment in the BRICS territories, this research contributes to the identification of factors influencing teachers' PD.

The practical implications of this research are also very vital and valuable. According to the analysis and proposed models, this research can be used as a practical guide for the development and implementation of learning environments compatible with AI in the BRICS countries. This research deals with providing approaches and solutions for managing the development chain of learning environments compatible with AI, identifying needs and developing educational programs, evaluating and confirming

proposed activities and products, analyzing data, and providing necessary improvements in the end.

There are also limitations of this research that may have an impact on the interpretation and application of its results. One of the limitations of this study is the limitation of using local data and the limitations related to access to the information needed to conduct the research. Furthermore, limitations related to the validity and reliability of data and research results can also be considered. In addition, methodological limitations related to sample selection, research method and tools used may also have an impact on the accuracy and reliability of the results of this research. As a result, in interpreting and using the results of this research, care should be taken with these limitations and attention to the issues related to them.

The suggestions for further research can introduce a path for advancing the knowledge and understanding of the role of AI in teachers' PD as well. As the current research concluded with recommendations for policymakers, educators, and institutional managers to successfully develop an AI-enabled learning platform for teachers' PD, it is suggested that further research should focus on analyzing the practical effects of this platform as well as improving learning methods compatible with AI in educational environments. Moreover, using local information and research findings alongside international research can help deepen understanding of the role of AI in teachers' PD. Besides, further research can be focused on examining and classifying instructional tools in teacher education that focus on adaptive learning and the use of AI to explore the limitations of their usage and suggest proper solutions to increase their effectiveness. In conclusion, the integration of adaptive learning with AI has a pervasive power that is capable of not only rewriting educational paradigms but also bringing about a fundamental transformation in education. By taking advantage of data-driven customization, instant feedback, and dynamic content delivery, adaptive learning systems can create a dynamic and interactive learning environment for teachers and students that expresses and enhances their abilities. The use of such systems not only increases the motivation and participation of users at the local level, but also allows them to determine the path of spontaneous learning in a wider area, enter a bigger competition, and, as a result, observe a significant improvement in their performance.

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