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Challenges in Artificial Intelligence Development in Higher Education in China, India, and Indonesia: International Students' Perspectives

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Abstract. This research explores the challenges of developing artificial intelligence (AI) at universities in China, India, and Indonesia for teacher education students. A qualitative research method was employed, with data collected through in-depth focus group discussions with 12 doctoral students from the 3 countries in equal proportions. The sample selection was based on the diversity of the participants' relevant backgrounds, experiences, and understandings. The data collected were analyzed using a thematic approach involving the identification, mapping, and interpretation of themes. The research findings indicate variations in the main challenges in developing AI to improve the quality of teacher education in each country. In Indonesia, infrastructure and Internet access are the main constraints limiting the application of AI technology. Meanwhile, in India, the main concern relates to the lack of human resources skilled in the field of AI, prompting the need for relevant skills development among educators. Conversely, in China, the problem concerns striking a balance between utilizing advanced AI technologies, safeguarding privacy, and developing the capacity to accommodate rapid advances in technology-based education. The findings of this study provide valuable strategic insights, enabling the design of appropriate strategies in each country. The implications of the findings can assist

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the relevant parties in overcoming specific barriers in the context of each country, supporting innovative developments in technology-based teacher education.

Keywords: artificial intelligence; China; higher education; India; Indonesia

1. Introduction

The presence of artificial intelligence (AI) in education marks a significant paradigm shift, changing the way information is accessed, presented, and managed (Liu et al., 2018). AI not only provides a personalized approach to learning but also allows teachers to focus on more creative and interactive aspects of teaching (Popkova & Gulzat, 2020). With advanced data analysis, AI can identify student needs, craft skillful curricula, and even provide instant feedback. Moreover, this technology enables the development of innovative online learning platforms, opening the door for wider and more inclusive access to education (El Naqa et al., 2020). By utilizing AI, education can become more adaptive and responsive and meet the evolving demands of society (Chen et al., 2020).

The importance of learning AI in the context of higher education is becoming increasingly fundamental, especially in countries in Asia with the largest populations of Internet users, such as China, India, and Indonesia. AI offers the potential for a major transformation in learning methods, opening opportunities for more adaptive and personalized learning experiences. Ghnemat et al. (2022) reported that integrating AI into higher education can create students who are skilled in mastering digital skills, such as complex problem-solving, programming, and understanding the latest technology. As stated by Liua et al. (2021), an understanding of AI can provide a strong foundation for young people to face global challenges, stimulate innovation, and prepare them to take on important roles in the knowledge-based economy. AI equips students with the necessary tools to face a future full of technological change.

So far, studies on AI have largely focused on positivistic research areas that seek to measure, assess, and even evaluate the utilization of AI in the context of learning. Nguyen et al. (2013), for example, successfully investigated the effectiveness of AI in biology learning, their analysis showing that, in Vietnam, AI on the Google Bard platform can help students increase learning motivation. Similar findings are also seen in Peek et al. (2013). In addition, research by Azimova et al. (2020) in Uzbekistan successfully measured the positive impact of AI in increasing medical students' interest, similar to Schaarup et al.'s (2023) research in Denmark. Along the same lines, Kosenchuk et al. (2023) conducted an analysis showing that the use of AI in school education in Finland can support the achievement of meaningful learning. While these studies detail many benefits in the European educational context, it is unfortunate that research on the challenges of using AI in Asia, especially in countries such as China, Indonesia, and India, is still

rare. This is important to illustrate the state of AI utilization in education in Asia, as these three countries are the largest Internet users in Asia (Ruamviboonsuk, 2020).

This research aims to analyze the challenges of AI development in the context of higher education in countries with the largest number of Internet users in Asia, namely China, India, and Indonesia. The paper begins by analyzing the most popular types of AI used in the three countries and describing the emerging landscape of AI applications and technologies. The next section discusses the integration of AI in higher education institutions in the three countries, revealing the extent to which these technological developments are permeating the education system. The focus then shifts to examining the challenges faced in AI development in India, China, and Indonesia, including aspects of regulation, infrastructure, and private sector engagement. The final section provides an in-depth analysis of the steps that need to be taken in the future development of AI education, highlighting collaborative efforts and innovations that can advance the sector in all three countries.

Doctoral students are a group that is intensively involved in the research and development of AI technologies in higher education (McAlpine & Norton, 2006). However, the challenges associated with the use of AI in the higher education environment are complex and require serious attention. This study is particularly important in higher education as it allows for better identification and understanding of the barriers faced by doctoral students in adopting and implementing AI technologies (Ning & Hu, 2012). By understanding these challenges, universities can develop appropriate strategies, curricula, and support measures to enhance the ability of doctoral students to utilize the full potential of AI in their research, thereby increasing their contribution to the overall development of AI science and technology.

2. Literature Review

A review of past research on AI has revealed significant developments in various aspects. Previous studies have tended to focus on the development of machine learning algorithms (Cholissodin et al., 2020), neural networks (Kumar & Thakur, 2012), and natural language processing techniques (Filchenkov et al., 2017). These studies also explored AI applications in various industries, such as healthcare, finance, and transportation (Abduljabbar, 2019). In addition, previous researchers have explored ethical issues related to AI, such as data privacy and security, and the socio-economic impact of job automation (Humerick, 2017). Overall, previous research has provided an important foundation for the further development and understanding of AI (Oseni et al., 2021), opening the door for new innovations and solutions to emerging challenges.

In the context of education, AI has made significant progress toward understanding its potential and impact. For example, Siau and Wang (2018) highlighted advantages such as personalization of learning, increased efficiency, and more precise feedback. However, limited attention has been paid to the

Asian region in addressing the challenges of AI development in education. Research detailing the specific barriers and opportunities faced by Asian countries is needed (Malik et al., 2005). Challenges such as differences in technological infrastructure, inequality of access, and sustainability of AI implementation in cultural and social contexts need further attention to ensure that these technological developments provide maximum benefits to education across the region (Kannedy & Fox, 2018).

A number of previous studies have intensively explored the role of AI in the context of education, with a primary focus on Western countries. However, there is a lack of studies on the challenges facing AI development in education in Asia, especially in countries such as China, India, and Indonesia (Gal, 2019). There is a gap in scholarly literature regarding an in-depth examination of the unique dynamics and barriers to adopting AI technologies in the education context in these three countries (Su et al., 2022). Each country has a different socio-cultural context and educational infrastructure, which may affect the implementation and acceptance of AI technologies in learning contexts (Ning et al., 2012). Therefore, further research is needed to explore the potential challenges and strategies that can advance the use of AI in education in Asia (Wong & Looi, 2024), including specific analysis of China, India, and Indonesia.

3. Research Methods

This research adopted a qualitative approach using focus groups as the main data collection instrument. In-depth focus group interviews were chosen as a more effective method compared to other qualitative approaches (Rabiee, 2004). This decision was based on the advantage of this approach in providing space for each participant to actively engage in in-depth discussions, allowing for the expression of diverse perspectives and understandings (Dilshad & Latif, 2013). As such, this approach facilitates the capturing of different views from all participants, while encouraging diverse responses to and explorations of the research questions.

The participants who were selected to share their views on the use of AI in education were chosen from the target population of second year doctoral students. It is believed that doctoral students have a sufficient level of experience and exposure to the implementation of AI in educational contexts (Peticca-Harris et al., 2016) since they are far along in their academic journey. The sample consisted of five students from Indonesia studying at Universitas Islam Negeri Walisongo Semarang, five students from India studying at University Teknologi Malaysia, and five students from China studying at Huazhong University of Science and Technology, China. The selection of these participants was based on the need to obtain representative and diverse data regarding the use of AI in educational contexts in different countries (Aguinis & Solarino, 2019). The participant profile is presented in Table 1.

Table 1: Participant profile

No.	Pseudonym	Nationality	Sex
1	I1	Indonesia	M
2	I2	Indonesia	M
3	I3	Indonesia	M
4	I4	Indonesia	F
5	I5	Indonesia	M
6	N1	India	F
7	N2	India	F
8	N3	India	M
9	N4	India	M
10	N5	India	M
11	C1	China	F
12	C2	China	M
13	C3	China	M
14	C4	China	F
15	C5	China	M

The focus group discussions took place online through the Zoom platform in three sessions, each consisting of 90 minutes for each respective country. The sessions were recorded after obtaining consent from all participants, and the recordings were utilized to capture non-verbal expressions. A moderator directed the discussion, addressing the challenges of implementing AI in the context of education in Indonesia, India, and China, respectively. The focus was on ensuring the discussion covered only the key aspects relevant to the research, while unrelated matters were avoided. The recorded and transcribed data were collected with guidance from the moderator, and the content was analyzed qualitatively by identifying concepts in the participants' responses. The concepts were then categorized into themes, and an examination was done of their intensity, depth, and specificity to the research questions (Mezmir, 2020). Special attention was paid to comments that were repeated or that received responses from multiple participants during the discussion.

4. Results

4.1 Platforms, Implementation, and Challenges of AI Development in Higher Education in Indonesia

Based on the confessions of the Indonesian participants, the most popular AI tools used in the context of higher education, especially in teacher education programs in Indonesia, are ClassPoint AI, ChatGPT, PowerPoint Speaker Coach, and Canva. Participant I1 confidently stated that the use of ClassPoint AI brings significant convenience in the development of interactive presentations. According to him, this advantage is in line with the characteristics of Indonesian education, which is increasingly adopting technology to improve the quality of learning. He considered that Canva and ClassPoint AI are very supportive in creating new learning media. This is important because it brings innovation and ease in delivering complex information to students. In other words, these AI tools not only provide practicality in presenting materials but also positively

contribute to the effectiveness of learning in educational environments. Canva is used to create images and animations, while ClassPoint AI will drive learning to be more engaging and efficient, creating an atmosphere conducive to students' cognitive development and creativity. Participant I1 expressed:

> *"I see many teachers choosing to combine Canva and ClassPoint AI as their primary solution. It stands to reason that these two AI platforms provide significant convenience in developing interactive presentations. These advantages are in line with the characteristics of Indonesian education, which is increasingly adopting technology. I think choosing ClassPoint AI to create questions from any PowerPoint slide, and combining it with Canva to create engaging designs, is very important because it brings innovation and ease in conveying complex information to students."*

Participant I3 reinforced this notion by stating that ClassPoint AI and Canva can be used synergistically to enhance the online learning experience. First, ClassPoint AI is a platform that allows teachers to present learning materials more interactively through features such as live questions and polls. By using ClassPoint AI, teachers can create more engaging presentations and activate student participation during learning. Meanwhile, Canva is a graphic design tool that allows users to create visually appealing learning materials. With Canva, teachers can easily create infographics, presentation slides, or other visual materials. Participant I3 added that integrating Canva with ClassPoint AI allows teaching students to insert attractive visual designs directly into their presentations. By using these two platforms together, teacher students can create a more engaging, interactive, and comprehensible learning experience. The implementation can be done by compiling learning materials that include visual designs from Canva and utilizing interactive features from ClassPoint AI during learning sessions.

> *"ClassPoint AI and Canva have their own strengths, which, when combined, can create a better learning experience. ClassPoint AI allows teachers to present learning materials interactively by using features such as live questions and polls. Meanwhile, Canva is a graphic design tool that allows users to create visually appealing learning materials. With Canva, teachers can easily create infographics, presentation slides, or other visual materials. The integration of the two gives teaching students the possibility to insert visual designs directly into their presentations, adding a significant creative dimension to learning."* (Participant I3)

In addition to using ClassPoint AI, Participant I2 mentioned that among the AI tools that are widely used in Indonesia are ChatGPT and PowerPoint Speaker Coach. He claimed to have conducted a survey regarding the use of popular AI tools with 267 undergraduate students as respondents. The analysis showed that 58% of the students favored ChatGPT, signaling high popularity in the use of conversation-based platforms. On the other hand, 40% of the students were skilled in using PowerPoint Speaker Coach, reflecting a positive acceptance of the tool for presentation training. These findings reflect the diversity of student preferences and skill levels in utilizing AI technologies to support learning and

communication. Participant I2 said:

> *"I once conducted a survey of 267 teacher students from one of the state universities. Fifty-eight percent said they liked using ChatGPT, forty percent liked PowerPoint Speaker Coach, and the rest did not like either. This choice was made because it was considered very helpful for students in doing their coursework."*

The combined use of ChatGPT and PowerPoint Speaker Coach is a potential innovation in improving the speaking and presentation skills of university students. Participant I4 explained that by utilizing ChatGPT, students can practice speaking spontaneously and improve their sentence structure. Furthermore, PowerPoint Speaker Coach can be used to provide immediate feedback on vocal expression, speaking speed, and presentation style. The process begins with users entering their presentation text into ChatGPT, which can provide suggestions on more engaging delivery and language. Subsequently, PowerPoint Speaker Coach provides practical exercises by directing users to practice their presentations, providing immediate feedback, and recording it for further evaluation. Participant I4 emphasized that the combination of the two provides an opportunity for users to comprehensively improve students' speaking ability, enhance their presentation skills, and ensure their message is conveyed effectively.

> "*ChatGPT can practice spontaneous speaking skills and improve sentence structure, while PowerPoint Speaker Coach can be utilized to provide instant feedback on vocal expression, speaking speed, and presentation style. The process begins with users entering their presentation text into ChatGPT, which will provide suggestions on more engaging delivery and word choice. Afterwards, the PowerPoint Speaker Coach provides practical exercises by giving users directions to practice their presentation, providing live feedback, and recording it for further evaluation.*"

The ClassPoint AI tool makes it easier for students to find learning information in a structured manner, while ChatGPT provides a text-based solution that supports user interaction with AI technology. On the other hand, PowerPoint Speaker Coach helps lecturers improve their presentation skills by providing real-time feedback. Meanwhile, the use of Canva provides convenience in graphic design and creation of teaching materials. These four tools were chosen for their superior functionality, which is in line with the specific needs in the context of higher education in Indonesia. The implementation of these AI tools proves that technology can positively contribute to the learning and teaching experience at the tertiary level, enriching learning methods and improving the effectiveness of material delivery.

Despite the many benefits, the integration of AI tools such as ClassPoint AI, ChatGPT, PowerPoint Speaker Coach, and Canva in teacher education in Indonesia faces various challenges. This can be seen from the need for curriculum adjustments that support the utilization of AI technology, training of lecturers to understand and integrate these AI tools in the learning process, and adequate technological infrastructure. In addition, the importance of mitigating

inequality of access to technology among students and lecturers is also a crucial aspect in optimizing the benefits of AI integration in vocational higher education. Participant I5 explained:

> *"I believe that adjusting the curriculum to support the utilization of AI technology in Indonesia is a must. Indonesia, as the third largest Internet user in Asia, should revise its curriculum to include aspects relevant to AI technology, such as programming skills development, data analysis, and artificial intelligence. Learning should be adjusted to enable students to understand basic AI concepts, develop problem-solving skills, and utilize technology productively. Student teachers also need to receive adequate training to teach AI-related subjects."*

In line with this, Participant I2 emphasized the importance of training lecturers to understand and integrate various AI tools in the learning process. With a deep understanding of AI tools, lecturers can improve the quality of their teaching, providing a more interactive and relevant learning experience for students. The use of AI tools in an educational context can enrich teaching methods, provide more personalized feedback, and assist in customizing learning materials according to individual needs. Through this training, lecturers can optimize the potential of AI technology to improve learning efficiency and effectiveness, create an innovative academic environment, and prepare students to face professional demands in the digital era. Participant I2 explained:

> *"Various trainings need to be conducted so that lecturers are able to integrate AI in higher education. This can be enriched by introducing the concept of AI, what applications can be used, and how to design these applications to be useful for improving the quality of students."*

Training lecturers and students to integrate various AI tools in lectures involves several key steps. First, an in-depth understanding of the basic concepts of AI and its application in an educational context is required. Lecturers need to be provided with up-to-date information on various AI tools that are relevant to their course material. Next, training should involve practical demonstrations of the use of these tools in a learning setting. The development of technical skills in operating and integrating AI technologies is also a key focus, including the application of AI-based learning methods. In addition, there needs to be a collaborative approach so that lecturers can share experiences and ideas in optimizing the use of AI in learning. Therefore, this training aims to equip lecturers and students with the necessary knowledge and skills to create innovative and effective learning experiences through the integration of various AI tools in their lectures.

At the end of the discussion, the five participants agreed that the main component that poses a challenge to AI development in Indonesia is the uneven availability of infrastructure and Internet access. Participant I3 explained that most regions in Indonesia still face limited Internet access, which can hinder the development of AI technology as a whole. This was reinforced by Participant I5, who explained that *"uneven technology infrastructure is a serious obstacle"*. Some remote areas may not be fully connected to a stable Internet network, making the implementation and adoption of AI-based solutions difficult. Participant I1

explained: *"Eleven percent of Indonesia still has no Internet signal, consisting of 5300 villages, of which 3500 villages are in the Papua region."*

The lack of Internet access and adequate technology infrastructure in Indonesia has a significant impact on the development of AI in higher education. Limited Internet access can prevent students and researchers from accessing digital resources, datasets, and AI platforms that are essential for research and development. In addition, the lack of technological infrastructure such as high-specification computers and the latest software can also be an obstacle in conducting experiments and testing complex AI algorithms. This is even more relevant for areas outside Java, as explained by Participant I5: *"Areas that often experience Internet disruptions, such as East Nusa Tenggara, West Nusa Tenggara, Papua, including small islands inhabited by people."* With these limitations, Indonesian universities may struggle to keep up with the latest developments in AI and to train students according to international standards. Therefore, greater investment in technology infrastructure and improved Internet access in higher education are crucial in advancing AI research and development in Indonesia.

4.2 Platforms, Implementation, and Challenges of AI Development in Higher Education in India

The Indian participants explained that the three popular AI applications used by teacher education students from India are BYJU's – The Learning App, ChatGPT, and AI Art Generator. Participant N1 said that BYJU's uses AI to present interactive and engaging learning content for students, including animated learning videos, adaptive practice exams, and curriculum-tailored learning materials. The app leverages AI technology to monitor student progress, provide personalized feedback, and adjust the curriculum according to individual needs. In addition, BYJU's also provides a wide range of learning content for different grade levels and subjects, making it a very popular tool among students and educators across India. Participant N1 explained as follows:

> *"BYJU's – The Learning App is a highly influential digital education platform in India. Its functionality is vast, providing interactive and innovative learning materials for students from grades 1 to 12, as well as for college-entrance-exam preparation. BYJU's uses teaching methods that focus on understanding concepts, rather than mere memorization, making use of animated videos, graphics, and other interactive content. In addition, the platform offers a curriculum that is customized to the individual needs of students and provides real-time feedback to aid their understanding. Through adaptive technology, BYJU's can identify students' weaknesses and strengths, present appropriate materials, and enhance learning in a personalized manner."*

In addition to BYJU's, Indian participants also mentioned ChatGPT and AI Art Generator as tools that are often utilized by Mandarin teacher education students. Participant N2 explained that by utilizing ChatGPT's ability to generate relevant and responsive text, learning platforms can present information intuitively and can be tailored to individual needs. Meanwhile, AI Art Generator can be used to create stunning visual elements, such as educational illustrations and interactive graphics, enhancing visual appeal and facilitating the

understanding of complex concepts. The integration of these two technologies can not only increase student engagement but also support inclusivity by presenting information through various sensory modes. Participant N2 emphasized that the use of ChatGPT and AI Art Generator in the context of learning media in India can bring significant innovation in advancing education through a more dynamic and fun approach.

> *"ChatGPT and AI Art Generator are commonly used in learning math, physics, chemistry, biology, and social studies for teachers in India to integrate the material using ChatGPT and AI Art Generator applications. The integration of the two can create stunning visual elements, such as educational illustrations and interactive graphics. This plays an important role in increasing learning motivation."*

Meanwhile, Participant N3 provided an example of the integration between BYJU's, ChatGPT, and AI Art Generator that he had applied in creating biology learning media on the theme of organ systems. BYJU's, as a leading digital learning platform, provides interactive content and curricula tailored to student needs. The ChatGPT tool is used to enhance interaction with students by providing informative and adaptive answers to their questions, creating a dynamic and personalized learning environment. Meanwhile, AI Art Generator plays a role in visualizing biology concepts through the creation of attractive images and illustrations, making it easier for students to understand the structure and function of body organs more visually. With this integration, the learning media create an engaging, immersive learning experience and help students understand the complexity of the organ system as a whole. Participant N3 said:

> *"I have combined the three tools (BYJU's, ChatGPT, and AI Art Generator) in learning biology. On the theme of body organs, AI successfully helped me create a dynamic and personalized learning environment. It encourages students to learn visually."*

Despite their many benefits, Participant N4 acknowledged that the use of BYJU's, ChatGPT, and AI Art Generator can have some negative impacts. First, BYJU's, as an online learning platform, can lead to dependency on technology, reduce direct social interaction, and trigger a tendency to rely on instant solutions rather than understanding concepts in depth. ChatGPT, although facilitating communication between humans and machines, can lead to a decline in interpersonal communication skills due to the lack of real human interaction. Participant N4 added that AI Art Generator has the potential to reduce students' authentic creativity because the resulting artwork tends to be more algorithmic than the result of personal expression.

> *"This technology provides many benefits, but we need to be aware of its potential negative impact on the development of students' social skills and creativity. BYJU'S can lead to dependence on technology and reduce direct social interactions. ChatGPT can cause a decrease in interpersonal communication skills. Even AI Art Generator has the potential to reduce authentic creativity."*

The study uncovered interesting challenges that India faces in developing AI as

an educational tool. Participant N5 explained that India is faced with challenges involving technology, infrastructure, and policy. He emphasized that unequal access to technology is a serious obstacle that limits the equitable application of AI in higher education institutions. This phenomenon is related to the disparity in digital infrastructure between regions, where urban areas tend to have better access to technology compared to rural areas. Factors such as lack of stable Internet connectivity, lack of adequate hardware, and lack of digital literacy in some areas complicate the introduction of advanced technologies such as AI. Moreover, economic challenges are also a hindrance, as most educational institutions in less developed areas face budgetary constraints to update and maintain technological infrastructure. Hence, these disparities pose a risk of inequality in access to and utilization of AI in higher education institutions, creating challenges for efforts to achieve equity in technology education across India. Participant N5 said:

> *"The challenges of developing AI for education in India are complex. The problem cuts across technology, infrastructure, and policy aspects. Other issues such as stable Internet connectivity, lack of adequate hardware, and lack of digital literacy in some areas complicate the introduction of this technology in schools. Not to mention the problem of digital-infrastructure disparity between urban and rural areas."*

At the end of the discussion, all five participants expressed the common view that the main challenges to AI development in India are the lack of trained resources and a supportive policy framework. Participant N4 explained that the lack of human resources trained in AI in India has been a significant bottleneck in the development and implementation of effective AI solutions: "*The limited number of adequate AI experts hinders technological progress and innovation in various sectors.*" Similarly, Participant N2 said that "*significant investments in technological infrastructure, such as reliable Internet networks and state-of-the-art hardware, are key in ensuring that AI solutions can be implemented optimally*". As if to provide a solution, Participant N1 explained the importance of training teachers so that they can utilize the full potential of AI in learning. A concerted effort to improve human resource capacity, along with investments in infrastructure and training, will be an important step in spurring the growth and adoption of AI technologies in India. There needs to be a clear policy framework to address ethical and privacy concerns that may arise along with the use of these technologies in higher education. These challenges mark the complexity and urgency of effectively integrating AI into the Indian higher education system.

4.3 Platforms, Implementation, and Challenges of AI Development in Higher Education in China

In the context of higher education in China, participants indicated that a number of AI tools have become very popular and dominate various education sectors, including Alibaba Cloud, Baidu's PaddlePaddle, and Tencent Cloud. Participant C1 revealed that the most popular AI tool is the Alibaba Cloud platform, which offers various AI services, such as data analysis, machine learning, and facial recognition. Alibaba Cloud has a significant role in the transformation of learning in China. The platform is widely used in educational

institutions to support information technology infrastructure. It provides reliable cloud computing services, secure data storage, and AI solutions. According to Participant C1, Alibaba Cloud enables educational institutions to host and manage online learning applications, such as online course platforms, online exams, and collaborative projects. He asserted that Alibaba Cloud's data analytics capabilities help educational institutions to optimize decision-making processes, personalize learning experiences, and improve administrative efficiency.

> *"By providing advanced technology infrastructure, Alibaba Cloud plays a key role in advancing the education sector in China. The platform enables educational institutions to host and manage online learning applications, such as online course platforms, online exams, and collaborative projects."*

Meanwhile, Participant C2 offered a different view. According to him, in his native city, Xinjiang, people prefer to use Baidu's PaddlePaddle. He explained that Baidu's PaddlePaddle plays an important role in facilitating the development of AI in various sectors, including industry, research, and education. The uses of PaddlePaddle include providing robust and easy-to-use infrastructure for machine learning researchers and practitioners, with support for tasks such as natural language processing, image recognition, and data analysis. Participant C2 emphasized the role of Baidu's PaddlePaddle in supporting machine learning initiatives in higher education institutions in China, helping students and researchers access advanced tools in the exploration and implementation of AI solutions. With a rich ecosystem, PaddlePaddle plays a key role in driving innovation and development of AI in China. He said,

> *"In Xinjiang, many people use PaddlePaddle. It provides a variety of algorithms and components that can be accessed flexibly. One of the advantages of PaddlePaddle is its ability to support complex deep learning tasks, including computer vision, natural language processing, and speech recognition. The platform supports integration with popular hardware such as GPUs and enables researchers and developers in China to easily access and apply artificial intelligence technologies in a variety of contexts, from industry to academic research."*

Participant C3 conveyed a different expression. He explained that in addition to the two platforms mentioned earlier, Tencent Cloud plays an important role in science learning in China by providing advanced cloud computing infrastructure. In the context of mathematics, Tencent Cloud facilitates the development and execution of intelligent algorithms to support the analysis of complex mathematical data. In biology, Tencent Cloud enables the storage and analysis of large genomic data, accelerating research in health and biotechnology. The participant also mentioned the usefulness of Tencent Cloud in learning physics, as the platform supports numerical simulations and modeling that require high computing power. In addition, in learning chemistry, Tencent Cloud facilitates molecular research and chemical structure analysis through flexibly accessible cloud computing solutions. Participant C3 revealed as follows:

> *"Tencent Cloud is making significant contributions to advancing science*

> *education in China by utilizing advanced technology to improve efficiency and accuracy in science learning. It has helped math, biology, chemistry, and physics teachers present engaging learning materials, and even refine the achievement of learning objectives in other scientific fields."*

The synergy between Alibaba Cloud, Baidu's PaddlePaddle, and Tencent Cloud has a very important role in supporting the development of education in China. Alibaba Cloud, with expertise in cloud computing and Big Data technology, provides powerful infrastructure for storing, managing, and analyzing education data. Baidu's PaddlePaddle, as an advanced AI platform, provides innovative solutions to improve learning efficiency through the use of AI technologies, such as facial recognition and analysis of student comprehension levels. Meanwhile, Tencent Cloud, with its comprehensive portfolio of cloud services, provides support for online education applications and platforms, creating a digital ecosystem that facilitates wider access to education. By working together, these three platforms create a profound synergy to advance China's education sector, delivering cutting-edge solutions and empowering educational institutions and individuals to reach their full potential in the digital age.

With respect to the challenges of AI development in China, Participant C4 explained that the development of AI in education in China faces a number of complex challenges. One such challenge is the balance between technological innovation and the protection of privacy and ethics. Participant C5 also shared this information: "*As technology grows, risks related to privacy violations and ethical issues are increasing*." The implementation of AI technologies in learning may present a threat to student privacy, requiring strict policies to protect personal information. In addition, there are concerns that the use of AI in education may cause students to become less creative, due to over-reliance on algorithms and structured curricula. Meanwhile, Participant C3 noted that there is also a risk of students becoming lazy "*due to the possible dependence on AI assistance, which may reduce motivation and effort to learn independently*". Therefore, serious efforts are needed to address these challenges to ensure that the development of AI in education has a positive and sustainable impact on student development.

Infrastructure issues are also proving to be a serious threat to the development of AI in China. According to Participant C4, several regions in China, such as Sichuan, Gansu, Qinghai, Xinjiang, Tibet, and Yunnan, are vulnerable to the threat of natural disasters. The presence of natural disasters in these regions poses a significant risk. Infrastructure related to the Internet and electricity, which are key components in AI development, could potentially be severely damaged by such disasters. This creates serious challenges in maintaining the continuity and sustainability of AI projects in China, requiring effective risk mitigation strategies to protect such vital infrastructure.

At the end of the focus group discussion, all five Chinese participants reached consensus that the main challenge in the development of AI in education in China is the risk of technological dependency, which could lead to social isolation. In this context, Participant C1 emphasized that "*the rapid development of*

AI technology may cause individuals, especially the younger generation, to become overly dependent on smart devices and applications". This phenomenon has the potential to create a less socially interactive society, as human interaction is replaced by interaction with technology. Participant C4 suggested that "*there needs to be a balanced approach to the application of AI technologies in education, ensuring that these developments do not simply improve learning efficiency*". The participant also recognized that this move could encourage healthy social engagement and the formation of interpersonal skills that are essential for the all-round development of individuals.

5. Discussion

The findings of this study show that the three countries studied, namely Indonesia, India, and China, have differences in the popular AI platforms used by their students. The participants' experiences show that in Indonesia, teacher education institutions widely use ChatGPT, Canva, and PowerPoint Speaker Coach. Conversely, in India, participants indicated using AI in the form of ChatGPT, BYJU's – The Learning App, and AI Art Generator. Other popular AI tools may not be well known by international students from Indonesia and India. Chinese participants indicated using Alibaba Cloud, Baidu's PaddlePaddle, and Tencent Cloud more. This shows the diversity of AI platform usage in each country (Goffi & Momcilovic, 2022), which may reflect the diversity of needs and preferences in education and technology development at the national level (Shams et al., 2023).

This study unequivocally confirms that the utilization of AI in the context of teacher education in Indonesia and India tends to be more focused on creating learning media, with the main goal of increasing students' interest in learning. This supports Rizal et al.'s (2020) research, which sees great potential for AI in enhancing the creativity of Industry 4.0-era learning. Meanwhile, in China, the use of AI has reached a more advanced stage, being not only limited to the development of learning media but also applied thoroughly in the learning process (Knox, 2020). This study concurs with Huang's (2021) analysis that AI implementation in China has included online courses, online exams, and collaborative projects, suggesting a more holistic and integrated approach to integrating AI technology into the educational environment.

Although the utilization of AI technology by the three countries looks different, they face similar challenges in infrastructure and Internet availability. In Indonesia, the problem of uneven Internet access and infrastructure that still needs to be improved is the focus to support the development of AI technology (Sartika et al., 2021). This includes areas far from Java, such as East Nusa Tenggara, West Nusa Tenggara, and Papua. In India, constraints include some areas still having slow Internet connections and the need for improved digital infrastructure in some underdeveloped areas, such as Bihar, Musahar, and Dharavi (Kaur et al., 2021). Interestingly, this study contradicts a previous analysis which indicated that technology education in China is operating without obstacles (Chen, 2022). Despite having capable infrastructure, it turns out that China has challenges in areas prone to natural disasters, such as Sichuan, Gansu, Qinghai, Xinjiang, Tibet, and Yunnan. As a result, Internet-related

infrastructure in these areas is prone to damage.

This study highlights three major challenges in the development of AI to improve teacher education in Indonesia, India, and China. In Indonesia, the main concern is the availability of infrastructure and Internet access, which are the main barriers to the implementation of AI technology in the context of education (Safitri & Noviadhista, 2020). Meanwhile, in India, the challenge is more focused on the shortage of human resources proficient in AI, creating a need for relevant skills development among educators (Alam, 2020). In China, the main focus is on striking the right balance between utilizing advanced AI technologies and maintaining privacy and ethics (Wang, 2022), as well as expanding capacity to accommodate the rapid development of technology-based education.

6. Recommendations

To overcome the challenges associated with infrastructure availability and Internet access, which are the main obstacles in the implementation of AI technology in Indonesia's education sector, a series of strategic steps needs to be taken. First, the government should increase investment in telecommunications-infrastructure development, especially in rural areas that are still marginalized (Satriawan et al., 2023). In addition, training programs for educators and students in the use of AI technology need to be strengthened so that they can make optimal use of it (Sajida & Ranjani, 2020). Partnerships between the government, private sector, and non-profit organizations can also be enhanced to ensure equitable and sustainable distribution of technology resources (Rufaidah et al., 2023). In addition, inputs from Akmal et al.'s (2021) study seemingly need to be considered in policies that support the development of AI technologies in the education sector, such as fiscal incentives and regulations that support innovation. This holistic approach is expected to create a favorable environment for the implementation of AI technology in improving the quality of education in Indonesia.

As for the education context in India, strategic steps need to be taken. First, the government and educational institutions should work together to improve curriculum and training program offerings relevant to AI (Alam, 2020). Financial support and incentives for students who choose an AI education path can also motivate more individuals to pursue acquiring such skills (Nath & Sahu, 2020). In addition, expanding collaboration networks between universities, industry, and business start-ups can help support the development of local talent in AI (Sandu & Gide, 2019). These efforts need to be reinforced by private sector initiatives to make available attractive employment and career development opportunities for AI experts. In addition, the empowerment of women and minority groups in this field needs to be considered to create an inclusive and diverse work environment (Sujath et al., 2020). Overall, holistic and collaborative solutions are key to addressing the shortage of AI-proficient human resources in India.

Furthermore, to strike the right balance between utilizing advanced AI technologies and maintaining privacy and ethics in China, important steps must

be taken. First, the government and technology companies need to work together to develop a clear and comprehensive regulatory framework to oversee the use of AI (Roberts et al., 2021). This could include strict privacy policies and clear ethical guidelines. In addition, it is necessary to raise public awareness about the importance of privacy and ethics in the development and use of AI technologies (Xu et al., 2021). Public education and campaigns can help improve people's understanding of the impact of AI technologies on privacy and ethics. Finally, it is important to encourage technological innovation that takes ethical values into account, so that technological development is in line with people's privacy needs and widely respected ethical norms (Gao et al., 2021).

Cooperation between Indonesia, India, and China in developing AI for teacher education could be a strategic move that has significant positive impacts. These three countries, with the largest populations and number of Internet users in Asia, have great potential to strengthen the AI ecosystem in the context of teacher education (Junaedi et al., 2023). By sharing knowledge and resources, they can build innovative and adaptive AI platforms to improve the quality of teacher education. This collaboration could include the development of smart algorithms for learning personalization, data analysis for teacher performance improvement, and the implementation of AI technologies in teacher training. Through this collaboration, Indonesia, India, and China can jointly address the challenges of teacher education with relevant and effective solutions, harnessing the immense potential of the trio to create a broad positive impact at the regional and global levels.

7. Conclusions

Based on the findings of this research, it can be concluded that the main challenges in developing AI to improve teacher education vary across Indonesia, India, and China. Indonesia faces major barriers related to infrastructure and Internet access that limit the implementation of AI technologies. In India, the focus is on the shortage of skilled human resources in the field of AI, driving the need for relevant skills development among educators. Meanwhile, participants from China highlighted the challenge of striking the right balance between utilizing advanced AI technologies, maintaining privacy, and developing the capacity to accommodate the rapid advancements in technology-based education. This research provides important insights that can help in designing appropriate and focused strategies to address country-specific constraints, creating a solid foundation for the improvement of teacher education through the implementation of AI.

This research has some limitations that need to be considered, however. First, since the research was restricted to India, Indonesia, and China, findings may not describe all the contexts or challenges involved in developing AI to improve teacher education worldwide. In addition, the analysis did not take into account regional or local variations that may affect the acceptance and application of AI technologies in the education sector. Nonetheless, the findings still point out the implication that each country has its own context that requires a specifically tailored approach in developing AI solutions for

teacher education. Therefore, this study encourages expanding the understanding of the barriers and opportunities faced by countries beyond India, Indonesia, and China. This can help in designing more comprehensive and inclusive strategies in applying AI technologies to improve teacher education globally.

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