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Pre-service Teachers' Education Needs for AI-Based Education Competency*

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This study aims to analyze the perceptions and educational needs of pre-service teachers for the use of Artificial Intelligence (AI) in education. To this end, we collected survey data from 25 undergraduate students who were enrolled in a teacher education college in Seoul. The purpose of the survey was to measure the importance and current performance for instructional AI use based on the technological, pedagogical, and content knowledge (TPACK) framework, and to explore the priority of educational needs using Borich's needs analysis and the Locus for Focus model. The results of the study confirmed that Ethics and TPK competencies are prioritized. Additionally, the results indicated a high demand for practical knowledge that can be implemented in the practice of education. Based on the results, it is necessary to develop a teacher education program that focuses on ethical aspects and teaching strategy competencies in AI-based education.

Keywords : Borich's needs analysis, Pre-service teacher education, AI-based education, Teacher competence, TPACK

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Introduction

The rapid development of science and technology, along with the emergence of new technologies like generative AI, necessitates changes and innovations in the educational environment. In response to this, the Ministry of Education of the Republic of Korea [MOE] (2023) has announced a plan for digital-based education innovation which includes the development of AI digital textbooks and the expansion of digital infrastructure, in order to realize personalized education. In addition, there have been revisions in terms of teacher expertise, specifically in the criteria for obtaining teacher qualifications. As part of these revisions, a new course on 'digital education (AI education)' has been included in the list of teaching subjects that pre-service teachers are required to complete (MOE, 2023). These societal efforts mean that the development and improvement of teacher competencies for future education needs to be systematically implemented in the pre-service teacher curriculum (Shin et al., 2012).

Discussions on future teacher competencies have been ongoing. As a key role in fostering future human resources, teacher competencies need to be organically changed and redefined according to paradigm shifts (Lee & Jo, 2012). However, the fundamental principles of teacher competencies remain largely unchanged, which emphasizes the importance of teachers' ability to efficiently cope with future changes based on their existing competencies and suggests that teacher education curricula should be competency-centered (Ko & Na, 2018). Baek & Kim (2020) emphasized the ability to select and utilize technology and the transdisciplinary knowledge needed to integrate technology with their teaching as competencies for future teachers. This implies the rise of the Technological Pedagogical Contents Knowledge (hereafter TPACK) competency, which emphasizes the mutual integration of a teacher's teaching expertise and technology.

Therefore, the AI competency of teachers required today should also be viewed as an approach in which AI is converged or utilized in the basic teaching competency

of teachers (Heo & Kang, 2023). Looking at previous studies on teachers' AI competencies several studies have been conducted to develop measurement tools and enhance teachers' AI competencies (Heo & Kang, 2023; Kim et al., 2023; Lee et al., 2022; Ng et al., 2023; Park et al., 2023), other studies have focused on exploring teachers' perceptions of AI education (Ayanwale et al., 2022; Kim, 2022; Park, 2021; Zulkarnain & Yunus, 2023).

In previous studies, both in-service and pre-service teachers demonstrated a strong understanding regarding the importance and benefits of AI-based education. However, their level of awareness of the simplicity and comprehension of AI-based education was relatively low. This suggests that there is a gap in the importance and present level of AI competency perceived by teachers, and that AI competency diagnosis and needs analysis studies are needed. However, there is still a lack of research on how pre-service teachers as future teachers perceive competencies and which competencies, they have high levels and needs for (Moon et al., 2016). Given the emphasis on the importance of TPACK in the integrated context of technology and instructional content, it is necessary to discuss AI-based education from the perspective of TPACK as well.

Therefore, this study aims to establish the groundwork for a future teacher education system by analyzing the perceptions and level of pre-service teachers for with respect to TPACK for AI-based education in order to determine their educational needs. This study is different in that it examines the detailed competencies and perceptions of pre-service teachers on AI-based education through the TPACK model. This is significant because it allows us to explore the status of teachers' competency development and more specific development directions for AI-based education. Accordingly, the research questions addressed in this study are as follows:

(1) What is the priority of educational needs for pre-service teachers' competencies for AI-based education in terms of TPACK?

(2) What is the priority of educational needs for pre-service teachers' behavioral

indicators for AI-based education in terms of TPACK?

Literature Review

AI-based education competency

AI-based education competencies include the knowledge, skills, and attitudes that teachers need to effectively integrate AI into their teaching, deepen students' learning experiences, and empower them (Ng et al., 2023). It is closely linked to the creation of meaningful learning environments, which is one of the primary responsibilities of teachers. AI competencies include both teaching AI knowledge and utilizing AI technologies in teaching, which is critical to a teacher's ability to teach AI (Holmes et al., 2019). Furthermore, it helps to personalize lessons and improve educational outcomes. Therefore, it is important to go beyond simply acquiring knowledge about AI technologies and instead focus on integrating and applying AI technologies in the classroom. This will help enhance students' AI competencies (Celik et al., 2022).

In this context, TPACK, a framework for a teacher's body of knowledge in technology-enhanced teaching and learning, is considered. TPACK is a model that integrates Shulman's (1986) Pedagogical Content Knowledge (PCK) with Technological Knowledge. It is described as the interaction between knowledge elements represented by Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPCK). Mishra & Koehler (2006), who proposed the model, stated that TPACK is the understanding of using appropriate technological tools for the purpose of teaching specific content by implementing effective instructional strategies. They also noted that the higher a teacher's TPACK competency, the better they can perform content-specific instructional methods using technology. As teachers' AI-based education

competency also includes to the application and integration of AI in education, it is necessary to discuss its convergence with TPACK, which promotes the understanding and practical use of technology in education.

Several studies have been conducted at home and abroad on the development of AI competencies and measurement tools for teachers. Based on the TPACK

Table 1
Compare AI-based education competencies

Celik (2023)	Heo & Kang (2023)	Park (2022)	Lee et al. (2022)	Park et al. (2021)	Kim et al. (2023)
Intelligent-TK	Understanding AI Computational thinking-based problem solving	Prepare for AI-based education	Understanding AI		Performing And embracing technology
Intelligent-TPK	AI course design Conducting AI classes	Designing instruction with AI	Creating AI-based learning environments	Curriculum Reorganization	Teaching
Intelligent-TCK	Developing AI educational resources	Run AI-based education	Reorganize Courses/ Classes	knowledge connection	
Intelligent-TPACK	Managing AI Education Evaluating AI education	AI-based educational professional development Evaluate AI-based education	Class Reflection and improvement		
Intelligent-Ethics	Practicing AI Ethics		Understanding AI Convergence Education Education evaluation and feedback		Cognitive

framework, Celik (2023) identified the educational AI utilization knowledge required for teachers and developed a measurement scale of TK, TCK, TPK, and TPACK for using AI-based tools. This proposed the Intelligent-TPACK framework, which is characterized by adding ethical aspects to the TPACK component and explored the relationship between each competency. Park (2022) developed a scale of AI convergence education teaching competencies for elementary and secondary school teachers by comprehensively identifying the competencies of teachers in AI Convergence Education and Software Education policy (Since it is the special Korean education policy name). In addition, Heo & Kang (2023) identified two areas (AI basics, AI utilization and integration) and eight behavioral indicators for teachers' AI competencies, focusing on AI convergence instructional design. As a result of comparing the AI education competencies developed in previous studies as shown in Table 1, it was found that Intelligent-TPACK includes most of the competencies.

Pre-service teachers' perceptions of AI-based education

Teacher education is the catalyst for change in education and human resource development. In particular, the education of pre-service teachers has a significant impact on the quality and competence of future teachers (Lee & Kwon, 2019). Therefore, the role of teacher education as a foundation for effective educational innovation is crucial. Teacher education is a crucial period during which teacher identity is shaped. This process has a significant impact on the entire teaching career and is considered the most effective approach to enhancing teacher quality (Park & Choi, 2022). Knowledge and competencies, in particular, that integrate theory and practice, such as TPACK, cannot be developed in a short period of time or through simple training. Therefore, curricula must be systematically developed (Eom et al., 2011).

However, compared to the importance of the use of AI in education, there is a lack of a specific educational system and method to enhance the AI competency of

preservice teachers. In this regard, Choi et al. (2022) recognized the importance of addressing both TK and CK of AI. To this end, they developed the AI-TPACK model for preservice teachers, which consists of a total of five courses, including the 'Understanding of AI' stage. Using this model, Park et al. (2023) explored the effectiveness of designing and applying a preservice teacher education program, but since they measured the AI teaching self-efficacy, it is difficult to say that they essentially explored the improvement of preservice teachers' AI competency.

To establish a foundation for an educational system, it is necessary to identify the present level of pre-service teachers and their educational needs. In a study analyzing the needs of teachers in the field of education regarding AI utilization competencies, teachers reported that they have lower levels of practical knowledge than content knowledge about AI (Lee, 2022), and they have high educational needs for curricula centered on practical experiences (Jeon et al., 2020). In addition, they have high educational needs for ethical competency, along with anxiety about technology dependence and information reliability in the educational use of generative AI (Hong & Han, 2023). Based on the previous studies, teachers' understanding of AI and theoretical knowledge competencies were higher than practical competencies, and they showed high educational needs for practical and ethical competencies for the educational utilization of technology. Therefore, in response to the need to identify more detailed educational needs for the effective use of AI in education, this study will measure the perceptions and present levels of Intelligent-TPACK competencies among pre-service teachers. The aim is to establish a solid groundwork for a future teacher education system.

Method

Participants

Twenty-five undergraduate students enrolled in a university in Seoul participated

in this study. There were sixteen female students and nine male students. All participants were pre-service teachers majoring in Korean language education at the teacher's college, and 22 of them were in their third year of study, except for two students who were in their second year and one student who was in their fourth year. The researcher distributed the survey to the participants. As a result, missing data were replaced by expectation–maximization (EM) algorithm, and twenty-three responses, excluding the responses of two asexual respondents, were used in the analysis.

Instrument

To examine the AI-based education competency of pre-service teachers from the perspective of TPACK, this study adopted the Intelligent-TPACK developed by

Table 2
Intelligent-TPACK Scale (Celik, 2023)

Competencies	Items	Examples	Cronbach's α	
			Present Performance	Importance
TK	5	I know how to interact with AI-based tools in daily life.	.904	.807
TPK	7	I can understand the pedagogical contribution of AI-based tools to my teaching field.	.834	.824
TCK	4	I know how to utilize my field-specific AI-based tools (e.g., intelligent tutor for Math).	.786	.762
TPACK	7	In teaching my field, I know how to use different AI-based tools for personalized learning.	.919	.783
Ethics	4	I can evaluate to what extent AI-based tools behave fair to all students in my teaching.	.783	.618
Total	27		.945	.885

Celik (2023). The questionnaire was composed of five areas including TK, TPK, TCK, TPACK, and Ethics and 27 behavioral indicators.

The questionnaire was translated into Korean and provided to the students. The students responded to the importance and present performance of each competency on a 5-point scale. Cronbach's α values for the itemized Importance and Present Performance responses ranged .618 ~ .945 indicating acceptable reliability.

Data analysis

To analyze the data, the researcher applied the prioritization method proposed by Cho (2009). First, a paired-sample t-test was conducted to analyze the difference between the importance and performance. Next, a Borich's needs analysis was conducted to explore the prioritization of educational needs. Borich's needs analysis (Borich, 1980) is a method of identifying the importance and present performance levels through a questionnaire. It involves assigning weights to the importance of each item and listing them in descending order. The greater the degree of weighted discrepancy, the greater the educational need for that competency (Yoon, 2022). The formula for Borich's needs analysis is

$$\text{Needs} = \frac{\sum(RL - PL) \times \overline{\text{RL}}}{N}$$

RL: $required\ level$ ($perceived\ importance$), PL: $present\ level$ ($Present\ Performance$), $\overline{RL}$: $average\ of\ the\ required\ level$, N: $total\ number\ of\ cases$

Finally, we utilized the Locus for Focus model (Mink, Shultz & Mink, 1991) to determine the quadrant position of each competency. The Locus for Focus model provides a visual representation of priorities divided into quadrants. The X-axis representing importance, while the Y-axis represents importance-performance. This model helps to facilitate a comprehensive understanding of priorities (Cho, 2009).

Competencies located in the first quadrant (HH) have both high importance and high importance-performance and are considered to have the highest educational needs, while competencies located in the third quadrant (LL) have both low importance and low importance-performance and are considered to have the lowest priority. The second and fourth quadrants can be considered as the second highest priority educational needs competencies.

The researcher conducted a comparative analysis of the results from this process to prioritize and rank the Intelligent-TPACK educational needs. Paired sample t-tests were conducted using IBM SPSS 25, while the researcher conducted the data analysis. The Borich needs analysis and Locus for Focus model were conducted using Microsoft Excel 2019.

Results

The priority of educational needs for Intelligent-TPACK

The results of analyzing the present performance and importance of Intelligent-TPACK are shown in Table 3. The importance of all competencies is higher than the present performance, and the difference is statistically significant. According to the

Table 3
Results of paired t-test and Borich's needs assessment model to examine Pre-service Teachers' Educational Needs for Intelligent-TPACK

Competencies	Importance		Present Performance		Mean Difference		*t*	Borich's educational needs	Borich ranking
	M	*SD*	*M*	*SD*	*M*	*SD*			
TK	4.02	.44	2.90	.88	1.11	.84	6.349***	1.03	3
TPK	4.17	.54	3.14	.72	1.03	.72	6.847***	1.07	2
TCK	3.99	.62	2.85	.79	1.14	.77	7.126***	1.02	5
TPACK	4.02	.52	2.60	.82	1.42	.80	8.529***	1.03	3
Ethics	4.21	.59	3.01	.84	1.20	.83	6.151***	1.08	1

***p<.001

Borich's needs analysis, Ethics is the highest need, followed by TPK, TPACK, TK, and TCK.

Next, the results of the analysis using the Locus for Focus model are shown in Figure 1. The importance of Intelligent-TPACK, as perceived by pre-service teachers, is 4.08 The mean difference between importance and present performance is 1.18. When the analysis was plotted on a coordinate plane with two axes, Ethics was in the first quadrant, indicating the highest educational needs. TPACK and TPK were found in the second and fourth quadrants, respectively. Finally, TCK and TK were situated in the third quadrant, representing the lowest needs.

Figure 1. The Locus for Focus model (Intelligent-TPACK)

Based on the results of the educational needs analysis (Table 4), we can conclude that Ethics has the highest educational needs. It was ranked first in both the Borich needs analysis and Locus for Focus. TPK, which ranked second in both analyses, was also found to have the next highest educational needs.

Table 4
Compare results from Borich's needs analysis and the Locus for Focus model (Intelligent-TPACK)

	TK	TPK	TCK	TPACK	Ethics
Borich ranking		2			1
Locus for Focus		Ⅳ		Ⅱ	Ⅰ

The priority of educational needs for behavioral indicators of the Intelligent-TPACK

The results of the educational needs analysis for each behavioral indicator of Intelligent-TPACK are shown in Table 5. Once again, the importance of all items was higher than the present performance, and the difference was statistically significant except for TPK2. TPK2 (I can evaluate the usefulness of feedback from AI-based tools for teaching and learning.), which did not show a significant difference, showed a higher present performance than other items. This suggests that pre-service teachers believe they have some ability to evaluate the usefulness of AI-based tools. However, the level of importance was somewhat lower. Considering the high importance of TPK4 (I know how to use AI-based tools to monitor students' learning.), TPK5 (I can interpret messages from AI-based tools to give real-time feedback.), and TPK7 (I have the knowledge to select AI-based tools to sustain students' motivation.) in the same TPK area, it can be seen that the ability to effectively use AI in educational situations is more important than evaluating its usefulness. The ranking of Borich's needs by item is as follows: Ethics2, TPACK5, Ethics1, TPK7, TPK5, TPK4, TK2, TPK3, TCK1, TPACK4. Among the competencies, Ethics and TPK behavioral indicators were the highest prioritized for educational needs.

Table 5
Results of paired t-test and Borich's needs assessment model to examine Pre-service Teachers' Educational Needs for behavioral indicators of the Intelligent-TPACK

Indicators	Importance		Present Performance		Mean Difference		*t*	Borich's educational needs	Borich ranking
	M	*SD*	*M*	*SD*	*M*	*SD*			
Ethics2	4.78	0.42	3.22	1.13	1.57	1.12	6.696***	6.67	1
TPACK5	4.61	0.58	3	1.09	1.61	1.12	6.903***	6.42	2
Ethics1	4.57	0.51	3.26	1.21	1.3	1.29	4.832***	6.36	3
TPK7	4.52	0.67	2.74	1.01	1.78	1	8.566***	6.3	4
TPK5	4.39	0.58	3.22	1.17	1.17	1.11	5.054***	6.12	5
TPK4	4.35	0.71	2.48	0.99	1.87	1.01	8.845***	6.06	6
TK2	4.13	0.46	3.17	0.98	0.96	0.88	5.225***	5.76	7
TPK3	4.13	0.87	3.3	1.15	0.83	1.34	2.964**	5.76	7
TCK1	4.13	0.87	3.48	1.2	0.65	0.93	3.347**	5.76	7
TPACK4	4.13	0.63	2.7	1.02	1.44	1.24	5.564***	5.76	7
TK4	4.09	0.67	2.65	0.98	1.44	1.16	5.927***	5.7	11
TPK1	4.09	0.9	3.7	0.7	0.39	0.84	2.237*	5.7	11
TK1	4.04	0.56	3.17	1.03	0.87	1.1	3.792**	5.64	13
TCK4	4.04	0.82	2.35	0.98	1.7	1.15	7.099***	5.64	14
Ethics3	4.04	1.02	3.09	1.04	0.96	0.93	4.942***	5.64	14
TPACK1	4	0.6	2.27	0.86	1.73	0.86	9.604***	5.58	16
TPACK3	4	0.74	2.48	0.99	1.52	0.99	7.342***	5.58	16
TPACK7	4	0.74	2.91	1.04	1.09	0.95	5.491***	5.58	16
TPK2	3.96	0.93	3.44	0.79	0.52	1.27	1.963	5.52	19
TCK2	3.96	0.77	2.35	0.78	1.61	0.99	7.808***	5.52	19
TK5	3.91	0.67	2.57	1.04	1.35	1.11	5.811***	5.46	21
TPACK2	3.91	1.12	2.44	0.95	1.48	1.41	5.028***	5.46	21
TK3	3.91	0.51	2.95	1.15	0.95	1.06	4.291***	5.44	23
TCK3	3.83	0.78	3.22	1.04	0.61	1.23	2.366*	5.33	24
TPK6	3.77	0.73	3.13	1.18	0.64	1.38	2.224*	5.26	25
TPACK6	3.48	0.95	2.39	1.03	1.09	1.16	4.477***	4.85	26
Ethics4	3.44	1.24	2.48	0.9	0.96	1.22	3.748**	4.79	27

*p <.05, **p<.01, ***p<.001

The results of analyzing the behavioral indicators with the Locus for Focus model are shown in Figure 2. The average importance of Intelligent-TPACK behavioral indicators perceived by pre-service teachers is 4.08, and the average difference between importance and present performance is 1.19. On the coordinate plane, seven items Ethics2, Ethics1, TPACK5, TPK7, TPK4, TPACK4, and TK4 were in the first quadrant of high demand, while nine items TPACK6, Ethics4, TPK6, TCK3, TPK2, TK1, TK3, TPACK7, and Ethics3 were in the third quadrant of low demand. The remaining behavioral indicators were located in the second and fourth quadrants.

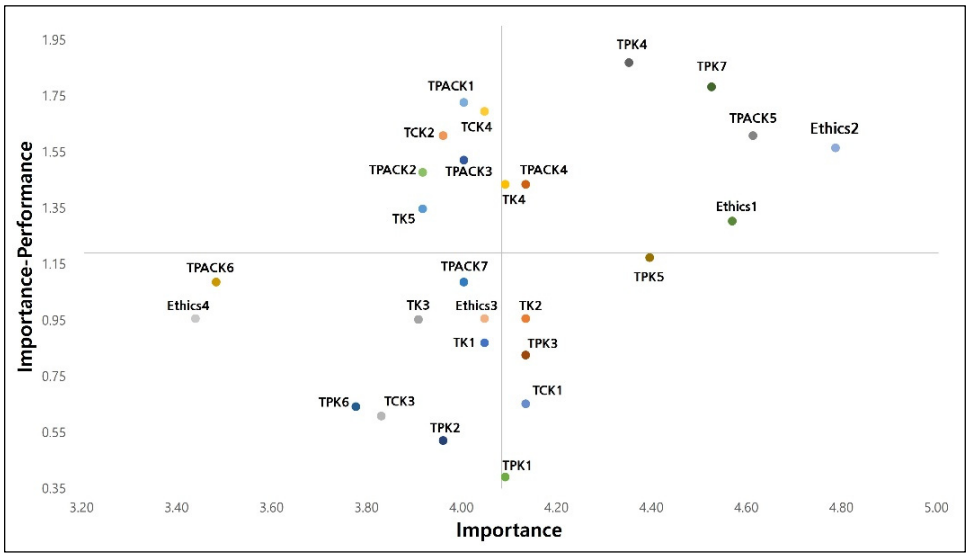

*Figure 2. The Locus for Focus model (*behavioral indicators of the Intelligent-TPACK*)*

To synthesize the results, we compared the Borich rankings of the seven behavioral indicators in the first quadrant of Locus for Focus as shown in Table 6.

Based on the Borich's needs analysis results, we have identified the behavioral indicators Ethics2, TPACK4, Ethics1, TPK7, TPK4, and TPACK4 as the top priorities. These behavioral indicators are located in the first quadrant of the Locus for Focus with high Borich rankings.

Table 6
Compare first-quadrant behavioral indicators

Code	Content	Borich ranking	Locus for Focus
Ethics2	I can evaluate to what extent AI-based tools behave fair to all students in my teaching.	1	I
TPACK5	I can teach lessons that appropriately combine my teaching content, AI-based tools, and teaching strategies.	2	I
Ethics1	I can assess to what extent AI-based tools consider individual differences (e.g., race and gender) of all students in my teaching.	3	I
TPK7	I have the knowledge to select AI-based tools to sustain students' motivation.	4	I
TPK4	I know how to use AI-based tools to monitor students' learning.	6	I
TPACK4	I can teach a subject using AI-based tools with diverse teaching strategies.	7	I
TK4	I have sufficient knowledge to use AI-based tools.	11	I

To determine the secondary behavioral indicators, we compared the Borich rankings of the behavioral indicators in the second and fourth quadrants using Borich's method. The results are presented in Table 7, Table8. The fourth quadrant (Table 7) contains items with higher-than-average importance, but a low degree of mismatch between importance and performance.

The second quadrant (Table 8) indicates that the importance is lower than average, but the degree of discrepancy (importance-performance) is higher than average. These can be prioritized because they are low in importance but require high performance. However, in this study, the competencies in the second quadrant were not selected as a secondary priority due to their low Borich ranking.

Table 7
Compare fourth-quadrant behavioral indicators

Indicators	Content	Borich ranking	Locus for Focus
TPK5	I can interpret messages from AI-based tools to give real-time feedback.	5	Ⅳ
TK2	I know how to execute some tasks with AI-based tools.	7	Ⅳ
TPK3	I can select AI-based tools for students to apply their knowledge.	7	Ⅳ
TCK1	I can use AI-based tools to search for educational material in my teaching field.	7	Ⅳ
TPK1	I can understand the pedagogical contribution of AI-based tools to my teaching field.	11	Ⅳ

Table 8
Compare second-quadrant behavioral indicators

Indicators	Content	Borich ranking	Locus for Focus
TCK4	I know how to utilize my field-specific AI-based tools (e.g., intelligent tutor for Math).	14	Ⅱ
TPACK1	In teaching my field, I know how to use different AI-based tools for adaptive feedback.	16	Ⅱ
TPACK3	In teaching my field, I know how to use different AI-based tools for real-time feedback.	16	Ⅱ
TCK2	I am aware of various AI-based tools which are used by professionals in my teaching field.	19	Ⅱ
TPACK2	In teaching my field, I know how to use different AI-based tools for personalized learning.	21	Ⅱ
TK5	I am familiar with AI-based tools and their technical capacities.	21	Ⅱ

The secondary behavioral indicators were TPK5, TK2, TP3, and TCK1, which are in the fourth quadrants with high Borich ranking. We also included TK4 because it was in the first quadrant but had a low Borich ranking.

Conclusion

This study aims to analyze the deference between pre-service teachers' perceived importance of AI-based education competencies and their present performance. It also seeks to identify the most prioritized competencies for enhancing AI-based education in the teacher education system by determining educational needs and identifying priorities.

The findings are as follows: First, we analyzed the educational needs of pre-service teachers by Intelligent-TPACK and found that Ethics was the highest. The present performance of Ethics was ranked second, which was not considered low. However, it showed the highest level of importance and achieved a high ranking in the Borich ranking. These results support the findings of many previous studies that emphasize the importance of ethical competencies for teachers in AI-based education (Hong & Han, 2023; Lee, 2020; Lee, 2022). In the study conducted by Velander et al. (2023), which examined teachers' perceptions of AI education through interviews based on Celik's (2023) framework, teachers expressed a strong interest in and understanding of the ethical aspects of AI-based education. However, they also expressed concerns and worries about its implementation in the classroom. As AI develops and new technologies emerge, teachers need to recognize the ethical issues associated with AI and take steps to ensure student safety (Ng et al., 2023). They will need to recognize the potential risks of relying solely on biased data analysis results for learning assessment. Additionally, they should strengthen their capacity to utilize secure AI-based tools in education.

After Ethics, TPK is the next skill with the highest training needs. With the emergence of the learner-centered education paradigm, the significance of utilizing

AI-based tools to provide feedback and scaffolding is growing. This means that AI technology can be used to facilitate learning beyond physical educational supports such as lesson content and classroom environments. It emphasizes the ability of teachers to leverage AI-based tools to facilitate learning. Currently, personalized learning systems such as chatbots and leveled course recommendations using generative AI are being actively used. While these aids cannot fully replace teachers in the entire process of teaching and learning, they are valuable in terms of their pedagogical utility and potential effectiveness. Kolchenko (2018) reported that AI has the potential to organize learning experiences and enable individualized adaptive learning, but it cannot replace the valuable teaching experience of teachers. Therefore, teachers should be able to explore various AI technologies and their potential as learning support tools based on their own pedagogical knowledge and experience context, and design effective teaching and learning to provide appropriate support for learners and subjects. In addition, TPK is related to competencies such as 'designing AI-based education' and 'creating an AI education environment' among the AI-based competencies of teachers that have been examined in previous studies. Therefore, pre-service teachers need to develop the ability to think about and practice how to utilize AI in educational situations, based on their understanding of the characteristics and concepts of AI technology.

After analyzing the educational needs of each Intelligent-TPACK behavioral indicator, the second research question, Ethics2, TPACK4, Ethics1, TPK7, TPK4, and TPACK4 were selected as the highest priority, and TK4, TPK5, TK2, TPK3, and TCK1 were selected as the second highest priority. In addition to the prioritized competencies of ethics and TPK, there was also a high demand for the detailed competencies of TPACK, indicating that the convergence of AI technology, curriculum, and educational context needs to be developed as core competencies. In particular, the highest prioritized competencies were interdisciplinary and practical, such as ethical consideration of fairness and bias in AI, and application of teaching strategies and content using AI. On the other hand, the second highest priority

competencies appeared to be fragmented knowledge and practices, such as knowledge and practice of AI utilization and tool selection, suggesting that education on complex and practical competencies should be prioritized over education based on theory and simple training. This finding supports previous studies (Choi et al., 2022; Lee & Jang, 2018) that have shown that preservice teachers' classroom experiences and experiences in constructing classroom environments like real-life situations affect their teaching expertise.

The implications of this study are as follows. First, to enhance teachers' AI education competencies, a teacher training system should be developed focusing on Ethics and TPK competencies. By acquiring strategies for utilizing AI to facilitate students' learning, along with ethical considerations for effectively integrating AI technology into the classroom, pre-service teachers can develop into educators in the digital society. Regarding ethical guidelines, MOE (2022) has released the Ethical Principles for Artificial Intelligence in Education. These principles can be referred to for guidance. Additionally, the establishment of a knowledge system and cases of teaching and learning using AI can serve as a great foundation for enhancing teachers' competency in utilizing instructional AI. Taken together, as we anticipate the introduction of 'AI digital textbooks', it is crucial to develop an appropriate AI-based teaching and learning model that requires ethical aspects and educational literacy. This will enable teachers to develop the ability to analyze the learner's characteristics of based on their understanding of the learning data collected and analyzed by AI. Also, they can then adapt learning data and design lessons in accordance with ethical guidelines.

Second, it is necessary to provide pre-service teachers with practical educational experiences related to Intelligent-TPACK. According to the educational needs analysis of each competency, the demand for practical competence in the classroom is very high, and the actual performance responses of pre-service teachers are more likely to answer TCK4 (I know how to utilize my field-specific AI-based tools (e.g., intelligent tutor for Math), TPACK2 (In teaching my field, I know how to use

different AI-based tools for personalized learning), and TPK4 (I know how to use AI-based tools to monitor students' learning). Given the high demand for experiential AI education experiences in previous studies (Jeon et al., 2020; Kim, 2022), it is necessary to provide practical tasks or projects that utilize AI-based tools for pre-service teachers. For example, they can analyze and monitor virtual learning data in an LMS environment for practice and provide assessment tasks utilizing AI-based tools. In addition, Experience-Based Learning, in which pre-service teachers practice the use of AI technologies in practical environments such as field trips and classroom demonstrations, will also help them develop their AI capabilities. Given the results of previous studies that show pre-service teachers who have practical learning experiences with AI perceive AI positively and adapt well to changes in school education (Park, 2021), it can be concluded that experience-based teacher training programs will enhance the competency of instructional AI use.

Although this study laid the foundation for the future teacher education system by exploring the educational needs of pre-service teachers for AI-based education, the number of subjects in the study was rather small, which limits the generalizability of the results. Therefore, in the future, it seems necessary to expand research to explore the educational needs for the use of AI in education by targeting a larger sample and can be further reflected in the curriculum.

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