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RESEARCH ARTICLE

Preservice Teachers' Beliefs about Integrating Artificial Intelligence in Mathematics Education: A Scale Development Study

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Abstract

Recently, AI has become a crucial tool in mathematics education due to advances in machine learning and deep learning. Considering the importance of AI, examining teachers' beliefs about AI in mathematics education (AIME) is crucial, as these beliefs affect their instruction and student learning experiences. The present study developed a scale to measure preservice teachers' (PST) beliefs about AIME through factor analysis and rigorous reliability and validity analyses. The study analyzed 202 PST's data and developed a scale comprising three factors and 11 items. The first factor gauges PSTs' beliefs regarding their roles in using AI for mathematics education (4 items), the second factor assesses PSTs' beliefs about using AI for mathematics teaching (3 items), and the third factor explores PSTs' beliefs about AI for mathematics learning (4 items). Moreover, the outcomes of confirmatory factor analysis affirm that the three-factor model outperforms other models (a one-factor or a two-factor model). These findings are in line with previous scales examining mathematics teacher beliefs, reinforcing the notion that such beliefs are multifaceted and developed through diverse experiences. Descriptive analysis reveals that overall PSTs exhibit positive beliefs about AIME. However, they show relatively lower levels of beliefs about their roles in using AI for mathematics education. Practical and theoretical implications are discussed.

Keywords: artificial intelligence, teacher beliefs, preservice teachers, scale development

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I. INTRODUCTION

Recently, artificial intelligence (AI) has been widely used in education with the development of machine learning and deep learning (Celik et al., 2022). According to a recent UNESCO report (Pedro et al., 2019), AI in education brings forth new challenges and opportunities for societal development, potentially altering every aspect of our lives. The report advocates for the integration of AI into educational systems by governments, educators, and institutions to improve student learning outcomes and enhance educational equity and quality.In tandem with these societal shifts, mathematics educators have started to incorporate AI-related tools, including robotics, chatbots, intelligent tutoring systems (ITS), and adaptive learning systems (ALS), to bolster mathematics education (Hwang & Tu, 2021). Notably, Lee and Yeo (2022) devised an AI chatbot aimed at supporting preservice teachers (PSTs) in refining their responsive teaching practices. Moreover, Francis et al. (2020) reported the effectiveness of robotics in enhancing students' spatial reasoning abilities.

AI proves beneficial for mathematics education across diverse facets (Hwang & Tu, 2021). The implementation of AI-based assessments enables teachers to precisely evaluate students' comprehension of mathematics concepts (e.g., Moltudal et al., 2020). Furthermore, AI plays a pivotal role in supporting student investigation, fostering discussions, facilitating interactions, and promoting self-monitored learning (e.g., Bush, 2021). These AI-integrated learning environments have demonstrated the potential to enhance student mathematics achievement and problem-solving skills. Noteworthy meta-analyses, such as those conducted by Athanasiou et al. (2019) and Ma et al. (2014), have highlighted the positive impact of AI-related tools on student mathematics achievement. Consequently, the integration of AI in mathematics education is poised to become an increasingly crucial element in both the current and future educational landscape.

Past research in mathematics education has explored the beliefs of PSTs regarding technology use (Philipp, 2007). For instance, Yang and Leung (2015) conducted an analysis of PSTs' beliefs concerning technology use in mathematics, discovering a prevalent belief that technology can aid in developing students' mathematical concepts and supporting their discovery and investigations. Similarly, Ndlovu et al. (2022) reported that PSTs perceived technology as a useful tool in the mathematics classroom. However, it is important to note that the roles and functions of AI differ from traditional technologies, such as calculators, Geometer's Sketchpad, and Cabri 3D, as AI has the capacity to learn, think, and perform tasks akin to human capabilities to achieve specific goals (Celik et al., 2022).

Given the importance of AI in education and our society, it is crucial to measure current PST’s beliefs about AI in mathematics education (AIME) and provide appropriate support for the development of positive beliefs. However, most currently available scales measuring PSTs' beliefs about AI do not specifically focus on mathematics education (e.g., AlKanaan, 2022). Furthermore, some scales were developed without conducting exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), resulting in a lack of reliability and validity (Li et al., 2023). Therefore, the goal of this study is to develop a scale that measures PSTs' beliefs about AIME. The findings of this study could also provide information on the current beliefs of Korean PSTs about AIME.

II. LITERATURE REVIEW

Definition and Characteristics of Mathematics Teachers' Beliefs

Beliefs, akin to attitudes and emotions, constitute a crucial component of the affective domain (Philipp, 2007). However, in contrast to other aspects of the affective domain, beliefs exhibit a close connection with cognitive domains. McLeod (1992) aptly observed that "beliefs, attitudes, and emotions represent increasing levels of affective involvement, decreasing levels of cognitive involvement" (p. 579). Beliefs are shaped over an extended period and tend to be resistant to change once established. Therefore, beliefs inherently resist change and necessitate personal effort and intentional learning experiences for the adoption of new perspectives. Cross (2009) provided a comprehensive definition, describing beliefs as ‘‘ideas and thoughts about oneself, the world, and one's position in it developed through membership in various social groups, and considered by the individual to be true" (p. 326). Despite some arguments equating beliefs with knowledge (Lewis, 1990), the prevailing view among scholars distinguishes beliefs from knowledge (Furinghetti & Pehkonen, 2002).

Mathematics teachers' beliefs encompass various constructs, including beliefs about teaching, learning, the nature of mathematics, and technology (Philipp, 2007; Thurm & Barzel, 2022). These beliefs wield a significant influence over their instructional practices and their endeavors to acquire pertinent knowledge (Ndlovu et al., 2022). Nevertheless, an interesting observation is that the alignment between mathematics teachers' beliefs and their actual practices is not always consistent (Thurm & Barzel, 2022). This incongruence is attributed to the fact that some beliefs hold a more central position, while others are considered peripheral, allowing teachers to maintain mutually exclusive beliefs without encountering internal conflict (Cross, 2009). Warfield et al. (2005) discovered that teachers who held the belief that mathematical knowledge is developed through people's investigation (a component of beliefs about the nature of mathematics) did not necessarily employ such methods in their classrooms, particularly if they doubted their students' ability to engage in such investigative practices (an aspect of beliefs about mathematics learning). Consequently, despite some scholars opting to amalgamate mathematics teachers' beliefs into a single construct (e.g., Barkatsas & Malone, 2005), the prevailing approach among researchers involves utilizing two or three distinct constructs to examine the various facets of mathematics teachers' beliefs (e.g., Tatto et al., 2012).

Mathematics Teachers' Beliefs about Technology and AI

The National Council of Teachers of Mathematics (NCTM, 2014) asserts that the integration of technology in mathematics classrooms is essential to support students in mathematical reasoning, communication, investigation, and problem-solving. Despite the recognized positive potential of technologies, some teachers remain hesitant to incorporate technology into their mathematics classrooms (Drijvers, 2015). The utilization of technology by mathematics teachers is affected by various factors, including teacher knowledge, school resources, curriculum, and national policies. Among these factors, teachers' beliefs about technology emerge as a critical determinant, serving to ‘‘frame, guide, and filter situations, actions, and intentions” (Thurm & Barzel, 2020, p. 1411). Consequently, teachers harboring negative beliefs about technology are less inclined to integrate it into their mathematics classrooms. Instead, they may favor traditional methods, believing that students learn best through drill and practice with pencil and paper, driven by these negative or unproductive beliefs (NCTM, 2014). Consequently, researchers emphasize the importance of fostering positive beliefs about the use of technology among mathematics teachers.

While there is difference between technology and AI, the integration of AI in classrooms also necessitates teachers' positive beliefs about AIME (Choi et al., 2023). Drawing on the Technology Acceptance Model (TAM) proposed by Davis (1989), it is established that mathematics teachers' perceived usefulness of technology significantly influences their decision to incorporate technology in their classrooms (Yeo et al., 2022). Similarly, the acceptance and utilization of AI in mathematics classrooms are contingent on teachers' beliefs about AIME (Choi et al., 2023). Consequently, for prospective educators such as PSTs cultivating positive beliefs about AIME becomes imperative, as these beliefs directly impact their motivation to acquire AI-related knowledge and shape their future instructional practices.

Defining positive and negative beliefs about AIME poses a challenge due to the diverse interpretations of both AI and beliefs. Drawing on the definition of positive beliefs (or constructivist beliefs) about technology (NCTM, 2014; Thurm & Barzel, 2022; Yang & Leung, 2015), it can be inferred that mathematics teachers with positive beliefs about AIME perceive AI as a supportive tool for teacher instruction and a means to enhance student learning. Conversely, teachers with negative beliefs about AI might hold the view that incorporating AI is time-consuming and has a detrimental impact on students' mathematical learning.

In a study by Shin (2020), the examination of perceptions about AIME among Korean secondary mathematics PSTs revealed predominantly positive beliefs (74%). These PSTs expressed that AI has the potential to enhance student learning interests, offering personalized and individualized learning experiences based on students' mathematical understanding. Furthermore, they highlighted the capability of AI to facilitate learning beyond the classroom, providing supplemental materials for mathematics education. Additionally, PSTs acknowledged that AI could contribute to accurate and objective evaluation of student performance, thereby supporting the implementation of student-centered instructional practices by alleviating teachers' workload. Nevertheless, some PSTs expressed concerns that learning experiences with AI might negatively impact the motivation and achievement of young students in mathematics, emphasizing the limitation of AI in emotionally interacting with students. Additionally, these PSTs raised concerns about AI's inability to accurately assess qualitative data, such as narrative and essay responses, and suggested that its capabilities might be confined to handling simpler questions. Similar findings have been reported by researchers in other countries who have explored PSTs' beliefs about AI, albeit without a specific focus on mathematics education (Attwood et al., 2020; Haseski, 2019; Mangera & Supratno, 2023).

AI Use in Mathematics Education

As the Fourth Industrial Revolution unfolds, numerous countries are actively engaging in initiatives to position themselves as leaders in AI-related industries (Pedro et al., 2019). The Ministry of Science and ICT (MSICT) in Korea unveiled the National Strategy for AI in 2019, outlining nine core strategies aimed at fostering AI businesses on a national scale (MSICT, 2019). Within the education sector, the report emphasized the imperative for in-service teachers to cultivate the capability to leverage AI and harbor positive beliefs about AI. As part of this vision, PSTs were urged to complete AI-related courses to equip themselves for future instructional practices.

To promote the integration of AI into education, the MOE (2022) has recommended incorporating AI education into mathematics classrooms. This suggestion is grounded in the understanding that fundamental mathematical concepts (e.g., probability, statistics, algebra, and calculus) are intricately connected to the core algorithms of AI, including machine learning, deep learning, and big data processing. In alignment with this guidance, a new subject titled "AI and Mathematics" has been introduced into the national mathematics curriculum. This addition aims to facilitate students' comprehension of AI algorithms through a foundation of mathematical knowledge.

According to the MOE(2020), students are encouraged to comprehend the process by which text and image data are transformed into numerical data through mathematical operations, including vector and matrix applications. Furthermore, the MOE (2021) has specifically addressed elementary students by developing a textbook titled "AI Lessons at School." This resource is designed to assist students in acquiring fundamental concepts and principles of AI, particularly in connection with mathematics. The content of the textbook encompasses activities such as (a) collecting, sorting, and analyzing data, (b) drawing and interpreting graphs, and (c) understanding letters, expressions, and rules. Beyond acquiring technical skills, students are also encouraged to cultivate a positive attitude toward the use of AI in mathematics.

AI has the potential to impact teachers' instructional practices, assessment strategies, and roles in education (Bush, 2021; Moltudal et al., 2020; Pedro et al., 2019; Schepman & Rodway, 2020). As AI analyzes student progress and supports independent learning, students may require less traditional teacher support. AI facilitates collaborative problem-solving among students, addressing complex challenges. Teachers benefit from AI by providing personalized support based on AI analyses. However, AI alone cannot change teachers' roles and practices; successful integration depends on positive teacher beliefs about AIME. Therefore, teachers and PSTs need to recognize AI's potential for new opportunities in mathematics teaching and learning (Pedro et al., 2019).

The Current Study

Given the increasing significance of AI in mathematics education, PSTs must cultivate positive beliefs about AIME. To support this development, teacher educators should assess the current beliefs of PSTs and offer appropriate support and feedback. As an initial step toward these objectives, this study aims to develop and validate a scale measuring PSTs' beliefs about AIME through the application of EFA, CFA, and reliability and validity analysis.

III. METHODS

Approval was obtained from the ethics review board of the first author's college to attain the research goals. Subsequently, we followed the methodology outlined by Hinkin (1998) for scale development, which comprised four key stages: (a) item generation and content validation, (b) questionnaire administration, (c) factor analysis, and (d) reliability and construct validity analysis.

Item Generation and Content Validation

To examine the constructs of AIME, we initiated the scale development process by drawing on insights from previous studies. Two initial scales were formulated one for beliefs about AI (e.g., Attwood et al., 2020; Haseski, 2019; Mangera & Supratno, 2023; Suh & Ahn, 2022) and another for beliefs about mathematics education (e.g., Barkatsas & Malone, 2005; Tatto et al., 2012). Items and questions from these existing studies served as the foundation for developing the scale used in this study. Given the relatively limited knowledge of AI and teaching experiences among PSTs, technical terms related to AI and education were intentionally excluded to enhance their understanding of the scale items. For instance, the scale's items intentionally avoided delving into specific functions and algorithms of AI; instead, they employed everyday language. The initial scale comprised 25 items, categorized as follows: five items assessing mathematics teachers' beliefs about their roles in using AI for mathematics education, 10 items gauging beliefs about using AI for teaching, and another 10 items capturing beliefs about using AI for learning.

The formulated items underwent scrutiny by three professors specializing in mathematics education and technology. All three professors possessed expertise in instructing AI to PSTs and had active involvement in AI-related studies. Their task was to assess the relevance of each item to PSTs' beliefs about AIME and to evaluate the accuracy of wording, format, and constructs. In response to their recommendations, certain words were modified, and eight items were removed. Consequently, the revised scale comprised 17 items, distributed as follows: three items pertaining to PSTs' beliefs about their roles in using AI for mathematics education, seven items concerning beliefs about using AI for mathematics teaching, and seven items addressing beliefs about using AI for mathematics learning.

Questionnaire Administration

Each item was structured with a five-point Likert scale, a format deemed appropriate for developing a new scale (e.g., Hinkin, 1998). The scale, initially designed in a paper format, was distributed to individual participants by the research assistant of the first author. To mitigate potential biases in responses—arising from a desire to make a positive impression on the first author—students' personal data were not collected. The survey was administered by the research assistant to uphold the confidentiality and anonymity of PSTs.

Furthermore, the research assistant left the classrooms following the distribution of the survey, allowing PSTs to respond to the items without external observation. Once the survey responses were completed, PSTs placed their surveys in a designated box. The research assistant also provided an explanation of the research goals and methods to enhance PSTs' understanding of the study. A total of 227 elementary PSTs completed the questionnaire, but 25 participants who did not respond to more than half of the items were excluded from the analysis. The final participant pool comprised 202 students, with 148 females and 54 males. The majority of participants were freshmen (94%), with a smaller representation of sophomores and juniors.

Data Analysis

The data analysis process involved factor analysis, reliability analysis, and validity analysis. Factor analysis, utilizing both EFA and CFA, was employed (DeVellis, 2017; Ho, 2014; Wang et al., 2023). EFA was employed to examine the factor structure of the collected data and determine the suitable number of factors for the scale (dimensionality reduction). Additionally, EFA assisted researchers in uncovering the realationship between each item and its corresponding factor (construct).

Subsequently, CFAwas employed to examine the goodness-of-fit of the collected data with the hypothesized models derived from previous studies on mathematics teachers' beliefs scales (e.g., Barkatsas & Malone, 2005; Tatto et al., 2012). The fit of the model was evaluated using several fit indices, including the chi-square test, root mean square error of approximation (RMSEA), comparative fit index (CFI), and Tucker Lewis index (TLI). Criteria for an acceptable model fit included RMSEA values less than .08, and CFI and TLI values exceeding .9, in accordance with established guidelines (Hair et al., 2010; Bentler & Bonett, 1980).

Reliability analysis was conducted using Cronbach’s alpha, where a value greater than 0.7 is considered indicative of acceptable reliability (DeVellis, 2017; Hair et al., 1998). To explore construct validity, composite reliability (CR) and average variance extracted (AVE) were employed. CR is similar with Cronbach’s alpha, and AVE “measures the level of variance captured by a construct versus that attributable to measurement error” (Wang et al., 2023, p. 7). Acceptable convergence is indicated by AVE values greater than 0.5 and CR values greater than 0.6 (Wang et al., 2023). Furthermore, correlations between each construct were examined to understand the data structure. The analysis utilized Mplus 8.3 and Excel.

IV. FINDINGS

The Results of Exploratory Factor Analysis

The EFA examined the relationships between each item and factors. In the initial EFA, three factors were extracted with 17 items. However, due to low factor loading scores, six items were removed, and a second EFA was conducted with 11 items (refer to Table 1 and the Appendix). The model from the second EFA showed a good fit with χ2 (25) = 53.977, p < .001, RMSEA = .076 (0.048-0.104), CFI = .960, TLI= .912. The loading scores ranged between 0.932 and 0.410, with values greater than 0.3, indicating a significant relationship between the items and factors (Costello & Osborne, 2005). These results signify a significant association between each factor and its corresponding items, suggesting that the items effectively elucidate the underlying constructs of each factor (Li et al., 2023).

Table 1. EFA outcomes

Item number	Factor		
	1	2	3
Item 1	0.932*		
Item 2	0.827*		
Item 3	0.989*		
Item 4	0.380*		
Item 5		0.770*	
Item 6		0.728*	
Item 7		0.811*	
Item 8			0.411*
Item 9			0.768*
Item 10			0.753*
Item 11			0.410*

Note. * $p < 0.05$

The Results of Confirmatory Factor Analysis

Moving forward, three CFAs were conducted to assess how well the data aligned with the hypothesized factor structure. Better fit indices signify a superior model. In line with previous studies on mathematics teachers' beliefs (e.g., Barkatsas & Malone, 2005; Tatto et al., 2012), three types of factor structures were compared (refer to Table 2): the original three-factor model (derived from EFA), a two-factor model, and a one-factor model.

The two-factor model comprised mathematics teachers' beliefs about their roles in using AI for mathematics education and beliefs about using AI for mathematics teaching and learning. The one-factor model examined mathematics teachers' beliefs about AIME and encompassed all items in a single factor. According to the outcomes of CFA, the three-factor model emerged as the best-fitting model for the data (χ2 (40) = 53.977, p < .001, RMSEA = .079 (0.057-.100), CFI = .931, and TLI= .905). The fit indices for the other models did not meet the criteria for a good fit and exhibited poor fits (Hair et al., 2010; Bentler & Bonett, 1980).

Table 2. Comparison of three model structures

Model (Item numbers)	x^2(*df*)	CFI	TLI	RMSEA
One-factor model - Beliefs about AIME (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11)	231.646 (43)	.739	.666	.147 (0.129-0.166)
Two-factor model - Beliefs about teachers roles in using AI for mathematics education (1, 2, 3, 4) - Beliefs about using AI for mathematics teaching and learning (5, 6, 7, 8, 9, 10, 11)	121.384 (42)	.879	.841	.101 (0.082-0.122)
Three-factor model - Beliefs about their roles in using AI for mathematics education (1, 2, 3, 4) - Beliefs about using AI for mathematics teaching (5, 6, 7,) - Beliefs about using AI for mathematics learning (8, 9, 10, 11)	89.878 (40)	.931	.905	.079 (0.057-0.100)

Reliability and Validity Analysis

In terms of reliability, the Cronbach's alpha and CR tests were employed, yielding values ranging between 0.784 and 0.887 (refer to Table 3). These values indicate that the scale is reliable and possesses internal consistency (Hair et al., 1998). Construct validity was assessed using CR and AVE estimates for factors. AVE estimates ranged from 0.607 to 0.555, while CR estimates ranged from 0.804 to 0.888. Given that all estimates exceeded the recommended criteria of 0.6 for CR and 0.5 for AVE (Wang et al., 2023), it can be concluded that the scale demonstrates reliability and construct validity, with items significantly correlated within the same factor.

Additionally, discriminant validity was assessed through fit indices, factor loading scores, and correlations between factors in the final model (refer to Table 3). All coefficient values were found to be significant, with standardized coefficients ranging from 0.581 to 0.857. Futhremore, bivariate correlations were examined, revealing significant relationships between all factors. The correlation values ranged from 0.192 (between factors 1 and 2) to 0.252 (between factors 2 and 3), indicating that each factor examines different constructs, even though they are domains within the same scale. In conclusion, the scale, comprising three factors with 11 items, demonstrates reliability, validity, and suitability for measuring PSTs' beliefs about AIME. The first factor, consisting of four items, assesses mathematics teachers' beliefs about their roles in using AI for mathematics education. The second factor, with three items, evaluates mathematics teachers' beliefs about using AI for mathematics teaching. The third factor, comprised of four items, explores mathematics teachers' beliefs about using AI for mathematics learning.

Table 3. Convergent validity, reliability, and factor structure of the final model

	Item	*B*	SE	*β*	*CR* AVE	Cronbach's alpha	Correlations		
							F1	F2	F3
F1	1	1.000**	–	0.853**	0.830 0.555	0.817	-	0.192*	0.234*
	2	0.919**	0.092	0.676**					
	3	1.604**	0.068	0.834**					
	4	0.697**	0.087	0.581**					
F2	5	1.000	–	0.842**	0.888 0.725	0.887	-	-	0.252*
	6	1.007**	0.076	0.855**					
	7	1.099**	0.066	0.857**					
F3	8	1.000**	–	0.694**	0.804 0.607	0.784	-	-	-
	9	0.910**	0.096	0.667**					
	10	0.843**	0.111	0.685**					
	11	0.973**	0.120	0.795**					

Note: F refers to factor. F1: Beliefs about their roles in using AI for mathematics education, F2: Beliefs about using AI for mathematics teaching, and F3: Beliefs about using AI for mathematics learning

B and β indicate unstandardized and standardized coefficients, respectively. CR and AVE indicate composite reliability and average variance extracted. * $p < 0.05$, ** $p < 0.01$.

Descriptive Analysis

The descriptive analysis based on the final model provides insights into Korean PSTs' beliefs about AIME. As depicted in Table 4, overall, PSTs exhibit positive beliefs about AIME. The mean scores for factors 1, 2, and 3 are 3.69, 4.33, and 4.12, respectively. However, there are comparatively lower scores in beliefs about teachers' roles in using AI. This suggests that while some PSTs acknowledge the utility of AI for mathematics teaching and learning, they may not see using AI as an inherent part of their role as teachers. Notably, the item measuring teachers' beliefs about using AI for mathematics assessment (item 2) obtained the lowest scores, implying that some teachers may hold the belief that mathematics assessment should be conducted without the use of AI (e.g., relying on traditional paper and pencil tests).

V. DISCUSSION AND CONCLUSIONS

Recently, AI has become a crucial tool in mathematics education due to advances in machine learning and deep learning (Celik et al., 2022). Educators are increasingly incorporating AI into mathematics classrooms, utilizing technologies like robots, ALS, ITS, and chatbots to enhance teacher instruction and student learning experiences (Hwang & Tu, 2021). The use of AI is essential for achieving educational equity by providing personalized learning and feedback to students (Pedro et al., 2019). Considering the importance of AI, examining teachers' beliefs about AIME is crucial, as these beliefs affect their instruction and student learning experiences (Bush, 2021; Moltudal et al., 2020; Schepman & Rodway, 2020).

Table 4. Descriptive information of PST's beliefs about AIME

	Item number	Item mean (SD)	Factor mean (SD)		Item number	Item mean (SD)	Factor mean (SD)
F1	1	3.74 (0.81)	3.69 (0.87)	F2	5	4.35 (0.64)	4.33 (0.66)
	2	3.52 (0.94)			6	4.33 (0.64)	
	3	3.58 (0.88)			7	4.32 (0.70)	
	4	3.93 (0.83)			–	–	
		-		F3	8	3.91 (0.83)	4.12 (0.76)
					9	4.12 (0.79)	
					10	4.23 (0.71)	
					11	4.24 (0.71)	

Note: F refers to factor. F1: Beliefs about their roles in using AI for mathematics education, F2: Beliefs about using AI for mathematics teaching, and F3: Beliefs about using AI for mathematics learning

If teachers have negative beliefs about AIME, the integration of AI into mathematics classrooms may face challenges. In essence, the integration of AI in the classroom necessitates teachers to hold positive beliefs about AIME, as AI alone cannot alter teachers' instructional practices. Teacher educators, therefore, bear the responsibility of supporting their students in cultivating positive beliefs about AIME. In alignment with this objective, the present study successfully developed a scale to measure PSTs' beliefs about AIME through factor analysis and rigorous reliability and validity analyses.

The results affirm that the developed scale stands as a reliable and valid instrument for assessing PSTs' beliefs about AIME. The scale, comprising three factors and 11 items, provides a nuanced assessment of these beliefs. The first factor gauges PSTs' beliefs regarding their roles in using AI for mathematics education (4 items), the second factor assesses teachers' beliefs about using AI for mathematics teaching (3 items), and the third factor explores teachers' beliefs about AI for mathematics learning (4 items). Elevated scores on the scale signify positive beliefs about AIME.

Additionally, an examination of fit indices for three different models was conducted to identify the most suitable model, considering the integration of the three factors into a one-factor or two-factor model (refer to Table 2). The outcomes of CFA affirm that the three-factor model outperforms other models, corroborating the results obtained from EFA. The findings from reliability and validity analyses further support the appropriateness of the three-factor model in accurately measuring PSTs' beliefs about AIME.

These findings are in line with previous scales examining mathematics teacher beliefs, reinforcing the notion that such beliefs are multifaceted and developed through diverse learning and teaching experiences (Cross, 2009). The three-factor structure of the AIME scale suggests that teachers who believe AI is beneficial for mathematics teaching (beliefs about using AI for mathematics teaching) may not necessarily incorporate AI into their classrooms (beliefs about their roles in using AI for mathematics education), as these are distinct constructs. Descriptive analysis, for instance, revealed that PSTs exhibit relatively lower levels of beliefs about their roles in using AI for mathematics education. However, further empirical studies are warranted to validate this assumption.

VI. IMPLICATIONS AND LIMITATIONS

The primary objective of this study was to develop a valid and reliable scale for measuring PSTs' beliefs about AIME. This research makes two important contributions. Firstly, it introduces a scale specifically designed to capture beliefs about AIME. While prior scholars have developed scales targeting teachers' beliefs about AI (e.g., Suh and Ahn, 2022) or mathematics teachers' beliefs (e.g., Tatto et al., 2012), scales specifically addressing AIME are scarce. This study fills that gap by synthesizing existing literature on AI and mathematics education to develop a novel scale. The developed scale stands as a valuable tool for researchers to assess current PSTs' beliefs about AIME.

Secondly, this study utilized a comprehensive array of statistical analyses, including EFA, CFA, and reliability and validity analysis. Consequently, the developed scale can more accurately measure PSTs' beliefs about AIME and offer insights into the current status of these beliefs. Thirdly, the unique focus on PSTs, as opposed to in-service teachers, is a notable aspect of this study. Recognizing the distinct lack of teaching experiences and knowledge among PSTs, it is acknowledged that a scale tailored for this group should differ from that intended for in-service teachers (Attwood et al., 2020; Haseski, 2019). Notably, some researchers have employed scales without distinguishing between in-service and PST populations. This study addresses such limitations by developing a scale exclusively using PST data, thereby enhancing the scale's relevance and applicability to the targeted demographic.

This study yields both research and practical implications. In terms of research implications, it underscores the importance of specificity when developing scales. While numerous researchers have crafted scales gauging teachers' beliefs about AI (e.g., Suh and Ahn, 2022), they often assessed teachers' overall beliefs about AI without considering specific subjects. Given the diverse roles and functions of AI across different types (Hwang & Tu, 2021), teachers may harbor varying beliefs contingent on the subject matter. Certain subjects, such as mathematics, might be more readily integrated with AI, while others, like physical education, could pose challenges. Future research should, therefore, endeavors to develop scales tailored to specific subjects.

Moreover, researchers should examine the reliability and validity of a scale using diverse statistical methods. The transformation from an initial 25-item scale to a final scale of 11 items, and the establishment of a three-factor structure as superior to one-factor and two-factor structures, were outcomes facilitated by rigorous statistical analysis. Contrastingly, certain researchers have developed scales and directly employed them for measuring participants' psychometric characteristics (e.g., Attwood et al., 2020). Such an approach may yield inaccurate conclusions. Therefore, it is imperative for researchers to employ various statistical analyses to ascertain the reliability and validity of the scale.

In terms of practical implications, teacher educators should assess their students' beliefs about AIME. This study revealed that, despite having positive overall beliefs about AIME, Korean PSTs exhibited relatively lower beliefs about using AI for mathematics assessment. Consequently, teacher education needs to offer targeted support to aid in cultivating a positive attitude toward AIME, recognizing that these beliefs play a pivotal role in shaping students' pursuit of knowledge and future instructional practices (Philipp, 2007).

This study has three notable limitations. Firstly, participants were exclusively recruited from a teacher education college, predominantly consisting of freshmen. Consequently, findings from a more diverse participant pool might yield different results. Subsequent studies should aim to replicate and validate the findings of this study across varied participant demographics. Secondly, all participants were students from the first author's college. Although measures were in place to ensure anonymity by having research assistants administer the survey, participants might still have been inclined to manipulate their responses to present a favorable impression to the author. Therefore, caution is advised when interpreting the findings of this study. Thirdly, PSTs' beliefs were evaluated based on self-reporting. While self-reported data is a commonly employed method in developing new scales (e.g., Yang and Leung, 2015), there exists the possibility that some PSTs may not have accurately understood or represented their beliefs. Future researchers might consider incorporating interview and observational data to provide a more comprehensive understanding of PSTs' beliefs about AIME.

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Appendix. The final scale

Item number	Item description
Item 1	Teachers should utilize AI programs and tools in mathematics classrooms.
Item 2	Teachers should utilize use AI programs and tools for mathematics assessment.
Item 3	Teachers should utilize AI programs and tools in mathematics classrooms to support student mathematics learning
Item 4	Teachers should utilize AI programs and tools in mathematics classrooms to provide accurate knowledge and information
Item 5	Teachers should utilize AI programs and tools in mathematics classrooms to implement various types of instructions.
Item 6	Teachers should utilize AI programs and tools in mathematics classrooms to increase student interest and motivation.
Item 7	Teachers should utilize AI programs and tools in mathematics classrooms to improve student mathematics achievement.
Item 8	The use of AI programs and tools is useful for supporting students' personalized mathematics learning.
Item 9	The use of AI programs and tools is useful for providing personalized feedback based on students' levels of understanding
Item 10	Students can utilize AI programs or tools for their mathematics learning outside of the school.
Item 11	The use of AI programs or tools is useful for improving students' engagement in mathematics when they study independently.