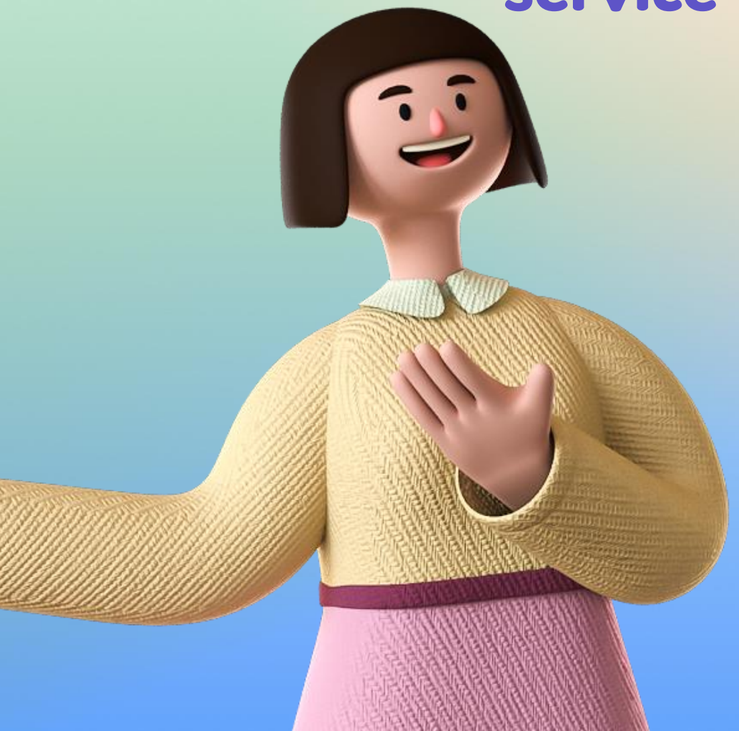
Review Journal

Artificial Intelligence Convergence Teaching Expertise Scale for Pre-service Teachers in Korea: A Validity and Reliability Study



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Artificial Intelligence Convergence Teaching Expertise Scale for Pre-service Teachers in Korea: A Validity and Reliability Study

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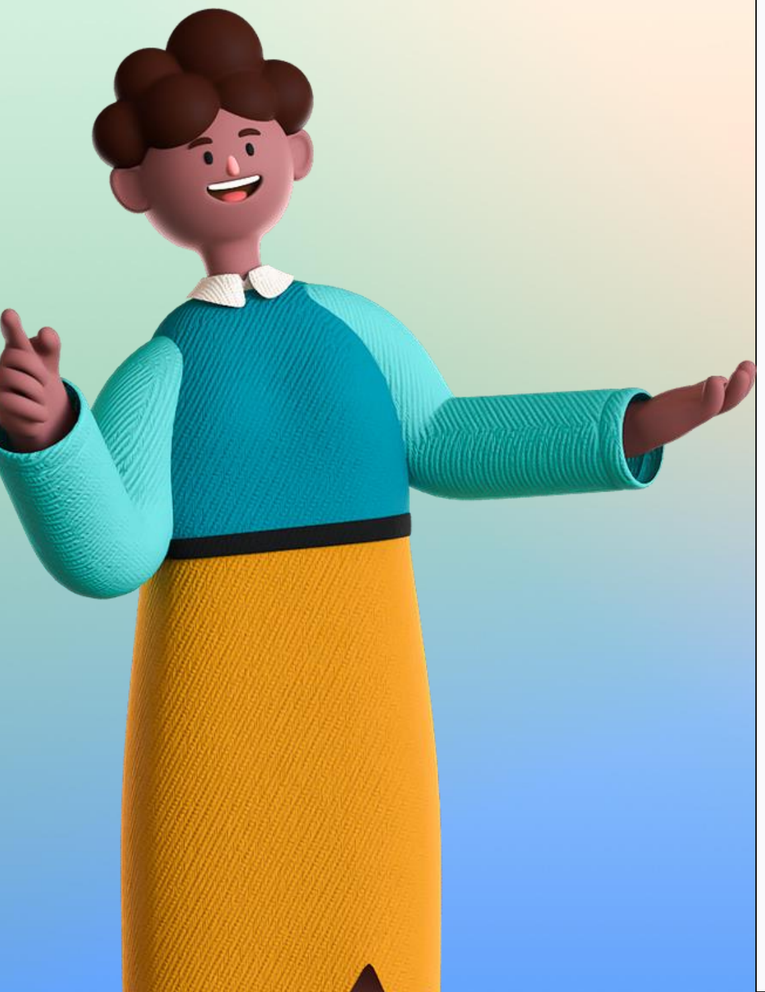

Novelty from this article

Novelty dalam jurnal ini dapat diidentifikasi dari beberapa aspek berikut:

1. **Pengembangan Alat Ukur Baru**:
   Jurnal ini mengembangkan alat ukur baru yang disebut *Artificial Intelligence Convergence Teaching Expertise Scale* untuk menilai kompetensi guru pra-jabatan dalam mengintegrasikan AI ke dalam pendidikan. Alat ini dirancang berdasarkan kerangka TPACK (*Technological Pedagogical Content Knowledge*) dengan menambahkan AI sebagai komponen teknologi, yang belum banyak dilakukan dalam penelitian sebelumnya.
2. **Integrasi AI ke dalam TPACK**:
   Penelitian ini memperluas kerangka TPACK dengan secara spesifik memasukkan AI sebagai alat teknologi. Pendekatan ini memberikan perspektif baru tentang bagaimana AI dapat diintegrasikan ke dalam pengetahuan pedagogi dan konten, yang belum banyak dieksplorasi dalam literatur sebelumnya.
3. **Validasi Empiris yang Komprehensif**:
   Alat ukur yang dikembangkan divalidasi melalui metode yang ketat, termasuk analisis literatur, survei Delphi, *exploratory factor analysis* (EFA), dan *confirmatory factor analysis* (CFA). Proses ini memastikan bahwa alat tersebut memiliki reliabilitas dan validitas yang tinggi (Cronbach's α 0,822–0,922).
4. **Fokus pada Guru Pra-Jabatan**:
   Kebanyakan penelitian sebelumnya berfokus pada guru yang sudah aktif mengajar (*in-service teachers*). Jurnal ini mengisi celah dengan berfokus pada guru pra-jabatan, yang merupakan populasi penting dalam mempersiapkan pendidikan berbasis AI di masa depan.
5. **Kontekstualisasi di Korea**:
   Penelitian ini memberikan contoh konkret tentang bagaimana kebijakan pendidikan AI di Korea (seperti kurikulum 2022 yang menekankan literasi digital dan AI) dapat diimplementasikan melalui pengembangan kompetensi guru. Hal ini memberikan kontribusi unik dalam konteks lokal sekaligus relevan secara global.
6. **Implikasi Praktis untuk Pendidikan Guru**:
   Alat ukur ini tidak hanya berguna untuk penilaian, tetapi juga dapat digunakan untuk merancang program pelatihan guru pra-jabatan dan pengembangan profesional guru aktif. Ini membuka jalan untuk penelitian lebih lanjut tentang pelatihan guru di era AI.

Novelty from the Article

Abstract—Artificial intelligence (AI) drives changes in various areas, including industry, society, and the economy, through technological innovation. In education, AI advancements are leading to innovations in teaching, learning, content, and assessment. Integrating AI into educational practices necessitates developing a tool to measure instructors' AI convergence teaching expertise, which is essential for implementing AI convergence education effectively. This study aimed to develop an assessment tool to measure pre-service teachers' AI convergence teaching expertise. A comprehensive and rigorous approach was adopted, involving a literature review, Delphi survey, exploratory factor analysis, and confirmatory factor analysis. The assessment tool was constructed by applying AI as a technological component within the Technological Pedagogical Content Knowledge (TPACK) framework to define AI convergence teaching expertise and derive relevant items. These items were administered to a sample of 202 pre-service teachers in Korea to validate their reliability and validity. The developed tool comprises 33 self-reported items across eight distinct factors, robustly measuring AI convergence teaching expertise. The Cronbach's α for the tool ranged from 0.822 to 0.922, indicating high reliability. The significance of this study is its potential application within educational settings to determine pre-service teachers' AI convergence teaching expertise. Furthermore, this study offers valuable implications for designing pre-service teacher education programs and ongoing professional development for in-service teachers. By accurately measuring and addressing AI convergence teaching expertise, this tool can contribute to advancing educational practices in the era of AI.

Keywords—AI convergence teaching expertise; pre-service teacher; TPACK; scale development.

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convergence education graduate programs and AI education

Research Gap

Meskipun integrasi kecerdasan buatan (AI) dalam pendidikan semakin berkembang, masih terdapat kekosongan yang signifikan dalam hal instrumen penilaian yang valid dan reliabel untuk mengukur keahlian pengajaran konvergensi AI pada guru prajabatan. Beberapa penelitian sebelumnya telah mengembangkan kerangka kerja untuk pendidikan AI atau literasi AI, namun belum secara komprehensif mengadopsi pendekatan yang menggabungkan AI sebagai komponen teknologi dalam kerangka **Technological Pedagogical Content Knowledge (TPACK)**. Selain itu, definisi pendidikan konvergensi AI yang masih bervariasi dan tumpang tindih dengan konsep pendidikan AI dan pemanfaatan AI menyebabkan ketidakkonsistenan dalam isi dan tujuan pelatihan guru. Fokus penelitian yang masih dominan pada guru yang telah berpraktik atau siswa, serta terbatasnya perhatian terhadap kebutuhan guru prajabatan, turut memperlebar kesenjangan antara kebijakan pendidikan AI dan implementasinya di lapangan. Oleh karena itu, pengembangan alat ukur yang spesifik untuk menilai keahlian pengajaran konvergensi AI pada guru prajabatan menjadi kebutuhan mendesak dalam mendukung keberhasilan transformasi pendidikan berbasis AI.

Jurnal ini juga mengakui keterbatasan, seperti perlunya validasi lebih lanjut untuk guru aktif dan penggunaan metode evaluasi yang lebih beragam (misalnya, berbasis kinerja). Hal ini menunjukkan kesadaran akan kebutuhan penelitian masa depan.

Research Gap from The Article

I. Introduction

Artificial intelligence (AI) is being utilized in various fields to solve existing problems or bring about efficient innovations. As AI's influence increases in computer science and traditional academic disciplines and industries, the capability to integrate AI to solve problems has grown in importance [1], [2]. Particularly with the development of generative AI, these innovations are rapidly progressing, and AI's disruptive impact is increasing as it merges with robotics [3].

In education, the application of AI has brought about rapid changes. Goals previously pursued in traditional education, such as learning analytics, personalized learning, and adaptive learning, are now being realized through AI [4], [5]. Consequently, there has been rapid advancement in AI-based courseware, programs, and platforms [5]. In Korea, various educational policies have been established to address the increasing use of AI in education, and initiatives such as AI convergence education graduate programs and AI education support projects are being implemented [6]–[9]. In addition, the 2022 revised curriculum centers on 'Digital and AI literacy,' making AI education mandatory in elementary and middle schools [10]. Furthermore, there are plans to develop AI-based digital textbooks and distribute them to schools by 2025 [11].

As AI is introduced into school settings, various educational policies and programs for learners and instructors are being implemented. However, teachers and pre-service teachers still need to be adequately prepared to utilize AI in education [6]–[9]. Therefore, courses aimed at developing the capability to integrate AI into teaching practices are being offered to both teachers and pre-service teachers [10], [12]–[14]. Despite these efforts, there are challenges in developing assessment tools to evaluate the capability of pre-service teachers to integrate AI into their teaching practices [12]–[14].

as "innovative education that aims to solve given problems by integrating AI with various subjects;" however, researchers have diverse definitions [12], [15]. In school settings, this ambiguity in the definition of AI convergence education leads to its confusion with AI education, AI utilization education, and AI value education [6], [12], [14], [16], [17]. Consequently, the capabilities required for pre-service teachers to practice AI convergence education also vary among researchers [6], [16]–[18]. This situation causes discrepancies in the content taught in AI convergence education courses for pre-service teachers, hindering the achievement of educational goals [15], [19].

To overcome these limitations, this study defines the capability to practice AI convergence education for pre-service teachers as AI convergence teaching expertise. It researches to develop an assessment tool to measure this expertise [15]. Although similar studies have been conducted, they still need to adequately consider the aspects necessary for integrating new technology, such as AI [8], [12], [14], [15]. Therefore, based on the Technological Pedagogical Content Knowledge (TPACK) framework, which relates to technology integration teaching expertise, this study developed an AI convergence education assessment tool. Research was also conducted to analyze the validity and reliability of the AI convergence education assessment tool for pre-service teachers.

2) *Delphi Survey:* In this study, the Delphi method was used to develop items to measure pre-service teachers' AI convergence teaching expertise. The Delphi method involves repeated anonymous feedback from an expert panel to reach a consensus in a field that lacks a theoretical framework [28], [29]. The expert panel consisted of 14 members, including professors, teachers, and researchers with expertise in AI convergence education and AI education. The Delphi survey was conducted twice, from December 2022 to March 2023. The initial Delphi survey, which typically begins with open-ended questions, was skipped, and the first round focused on using a 5-point Likert scale to evaluate the appropriateness and validity of the factors and the 51 items initially derived. Feedback was collected on the factors and items to improve them. The second Delphi survey revised items with low content validity based on the first round and modified items according to expert feedback. The same expert panel then used a 5-point Likert scale to evaluate the revised items for appropriateness and validity [30]. This process led to the extraction of items to measure pre-service teachers' AI convergence teaching expertise. Overlapping items were integrated, and four items deemed inappropriate for pre-service teachers were removed. Consequently, 47 items were derived through the Delphi process.

3) *Preliminary Survey:* Using the items derived from the Delphi survey, a preliminary survey was conducted in June

METODE PENELITIAN

❖ Pendekatan komprehensif: tinjauan literatur, survei Delphi, analisis faktor eksploratori (EFA), dan analisis faktor konfirmatori (CFA).
❖ Partisipan: 209 calon guru dari berbagai bidang studi.

Prosedur Penelitian

Pengembangan Item Awal:

- **Analisis literatur**: 58 item diekstrak dari studi TPACK dan konvergensi AI.
- **Survei Delphi**: 14 ahli mengevaluasi item (2 putaran), menghasilkan 47 item.
- **Survei Pendahuluan**: 20 calon guru menguji kejelasan item, menghasilkan 45 item.

Validasi Alat:

- **Subjek**: 209 calon guru (60% pria, 40% wanita; berbagai jurusan).
- **EFA**: 33 item akhir dengan 8 faktor (varians kumulatif 73.212%).
- **CFA**: Model fit baik (CMIN/DF=1.741; CFI=0.923; RMSEA=0.060).

B. Analisis Data

- **Reliabilitas**: Cronbach's α tinggi untuk semua faktor (0.822–0.922).
- **Validitas**:
  - *Convergent validity*: AVE > 0.5, CR > 0.7.

Discriminant validity: Korelasi antar-faktor signifikan ($p < 0.001$).

Factor	Variable	Factor analysis				Cronbach α
		Factor loadings	Communality	Eigenvalues	Explained variance (%)	
CK	CK1	0.827	0.786	3.276	9.928	0.922
	CK2	0.817	0.778			
	CK3	0.807	0.786			
	CK4	0.710	0.727			
TK	TK1	0.742	0.657	2.694	8.164	0.850
	TK3	0.623	0.700			
	TK4	0.605	0.715			
	TK5	0.584	0.690			
	TK6	0.532	0.690			
PK	PK1	0.760	0.674	3.477	10.536	0.891
	PK2	0.728	0.808			
	PK3	0.717	0.808			
	PK5	0.657	0.838			
XK	XK1	0.738	0.696	1.960	5.941	0.863
	XK2	0.703	0.777			
	XK3	0.562	0.764			
TCK	TCK1	0.769	0.720	2.996	9.079	0.884
	TCK2	0.734	0.698			
	TCK3	0.675	0.684			
PCK	PCK2	0.766	0.822	3.099	9.392	0.822
	PCK3	0.755	0.811			
	PCK4	0.714	0.680			
	PCK5	0.569	0.718			
	PCK6	0.496	0.623			
TPK	TPK2	0.688	0.702	1.912	5.794	0.836
	TPK3	0.679	0.639			
	TPK6	0.556	0.609			
TPACK	TPACK1	0.777	0.825	4.745	14.378	0.827
	TPACK2	0.769	0.796			
	TPACK3	0.764	0.740			
	TPACK4	0.753	0.774			
	TPACK5	0.658	0.761			
	TPACK6	0.655	0.664			

2) Reliability and Correlation Analysis: Reliability testing was conducted to examine the internal consistency of the items. The overall Cronbach's α was 0.956. For each factor, the Cronbach's α values ranged from 0.822 to 0.922 (see Table 2). Additionally, no items were found that would increase the Cronbach's α value if removed. This confirms that the AI convergence teaching expertise assessment tool for pre-service teachers is highly reliable. The correlation between factors within the assessment tool was analyzed. The subfactors of the AI convergence teaching expertise assessment tool exhibited significant correlations with each other. Therefore, the subfactors derived from the factor analysis are organically related and form a single latent construct. The results of the correlation analysis for the assessment tool are presented in Table 3.

TABLE III
PEARSON CORRELATIONS BETWEEN SUBFACTORS

	CK	TK	PK	XK	TCK	PCK	TPK
CK	-						
TK	0.567***	-					
PK	0.397***	0.459***	-				
XK	0.426***	0.516***	0.618***	-			
TCK	0.559***	0.642***	0.378***	0.564***	-		
PCK	0.366***	0.437***	0.579***	0.480***	0.397***	-	
TPK	0.403***	0.577***	0.499***	0.575***	0.548***	0.557***	-
TPACK	0.469***	0.610***	0.483***	0.539***	0.564***	0.644***	0.710***

*$p < 0.001$

Kelebihan

Prosedur pengembangan alat sistematis (Delphi + EFA/CFA).

Relevansi tinggi dengan kebijakan pendidikan AI di Korea.

Kekurangan

Generalisasi terbatas karena sampel homogen (calon guru Korea).

Tidak mencakup aspek etika AI yang semakin kritis dalam pendidikan.

Conclusion

Penelitian ini berhasil mengembangkan alat penilaian yang valid dan reliabel untuk mengukur keahlian mengajar konvergensi AI calon guru di Korea. Alat ini tidak hanya memberikan kerangka evaluasi yang komprehensif tetapi juga membuka jalan bagi pengembangan program pelatihan yang lebih terstruktur dalam mempersiapkan calon guru menghadapi tantangan pendidikan di era AI.

Conclusion

IV. Conclusion

With the increasing use of AI in education, the importance of teaching competencies that integrate AI into lessons is growing. Consequently, various policies and research related to AI convergence education are being conducted in Korea. In line with this trend, this study developed an assessment tool to measure pre-service teachers' AI convergence teaching expertise. The study analyzed prior research to derive the factors and initial items for AI convergence teaching expertise based on the TPACK framework to achieve this. Additionally, a Delphi survey was conducted to develop preliminary test items, and then exploratory and confirmatory factor analyses were performed based on the results of the initial test items. The conclusions drawn from this study are as follows:

First, a literature analysis determined that AI convergence teaching expertise for pre-service teachers was defined as the ability to effectively conduct lessons using AI-related technologies by the subject content and teaching-learning situations, considering the educational context. This expertise involves the theoretical and practical capabilities to design, implement, evaluate, and reflect on AI convergence lessons through the interaction of TK, CK, and PK based on XK. This definition integrates AI as a technological tool within the TPACK framework, with subfactors corresponding to TK, CK, PK, XK, PCK, TCK, TPK, and TPACK.

Second, an assessment tool was developed to measure pre-service teachers' AI convergence teaching expertise. A Delphi survey, exploratory factor analysis, and confirmatory factor analysis developed 33 items evaluated on a 5-point Likert scale. The items were designed for pre-service teachers in Korea, with the assessment tool taking approximately 10–15 minutes to complete. The reliability of the assessment tool was 0.956, with subfactor reliability ranging from 0.822 to 0.922. Furthermore, the assessment tool's discriminant, construct, and content validity were verified, confirming its suitability for measuring pre-service teachers' AI convergence teaching expertise.

This study has the following limitations: The research was developed for pre-service teachers; however, practicing

Second, this study is highly relevant to the current context, in which interest in AI and the demand for AI convergence education are increasing in schools. Generally, assessment tools have been developed to measure attitudes and literacy among elementary and secondary students. This study is significant in that it measures the development of AI convergence teaching expertise of pre-service teachers in line with the activation of AI convergence education in schools. This study presents a cross-disciplinary context for using AI in schools, which will serve as a reference for future research on the subject-specific characteristics of AI convergence education.

Third, the developed assessment tool can contribute to guiding the direction of AI convergence education for pre-service teachers. In Korea, various subjects and courses related to AI convergence education are being established in graduate schools and other educational institutions. However, a lack of clear guidelines for AI convergence education leads to significant variation in the subjects and content taught across schools. This study provides directions regarding what should be taught regarding AI convergence education for pre-service teachers.

Acknowledgment

This work was supported by the National Research

Suggestions

- **Perlu validasi lebih lanjut dengan sampel lebih luas dan metode evaluasi alternatif (mis. *performance-based assessment*).**
- **Penelitian lanjutan untuk menguji alat ini di konteks lintas budaya.**
- **Menambahkan studi longitudinal untuk melihat dampak alat ukur pada peningkatan kompetensi guru.**
- **Eksplorasi penerapan alat ini dalam konteks pembelajaran spesifik (mis. STEM).**

Suggestions

suitability for measuring pre-service teachers' AI convergence teaching expertise.

This study has the following limitations: The research was developed for pre-service teachers; however, practicing teachers also play a crucial role in implementing education in schools. Therefore, further research is needed to analyze the validity of the assessment tool for in-service teachers. Additionally, continuous post-validation is required to ensure the tool's validity, determine stable utilization methods, and prove the tool's applicability. Therefore, correlation studies with prior research on AI convergence teaching expertise are needed to verify construct validity.

The assessment tool developed in this study requires further refinement to achieve a precise and singular factor structure. During the development process, many items were deleted, and other factors were revised and supplemented. Future research should use the deleted items to revise and supplement the factors. Given the diverse definitions and perspectives on AI convergence education among researchers, it is essential to consider the different aspects or perspectives each assessment tool aims to measure.

Lastly, while the assessment tool developed in this study contributes to measuring AI convergence teaching expertise, it employs a self-reporting evaluation method. Although this method is convenient, it has limitations in assessing teaching competencies. Evaluations should include various forms, such as performance-based assessments, interviews, and rubric-based evaluations of artifacts. Future research should analyze the correlations with multiple evaluation tools and verify the effectiveness and validity of the assessment tool developed in this study.

The implications of this study are as follows: This study defined the AI convergence teaching expertise of pre-service teachers based on the TPACK framework and developed an assessment tool accordingly. While prior research has focused on defining teacher competencies for AI education, educational environments, and AI utilization education, this study is significant in developing an assessment tool based on the TPACK framework that can be used in school settings.