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Giving the Teacher AI Self Efficacy Measure a Psychometric Tune Up: Revalidating in the Pakistani Context

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ABSTRACT

The study intended to revalidate an instrument of the Teacher AI Self-Efficacy consisting of 31 items under six dimensions. The dimensions included AI Knowledge, AI Pedagogy, AI Assessment, AI Ethics, Human-Centred Education, and Professional Engagement. The sample of piloting the instrument comprised 313 female secondary school teachers selected through stratified random sampling from public girls' secondary schools in Central Punjab (districts including Lahore, Faisalabad, Gujranwala, Sahiwal, and Sargodha). The instrument was revalidated in the local context of Punjab, Pakistan, through content validity, construct validity, and reliability procedures. The content validity yielded a Scale-Level Content Validity Index (S-CVI) of 0.78. The construct validity through Exploratory confirmatory factor analysis (CFA) demonstrated factor loadings ranging from .58 to .82 across all 31 items, with all loadings exceeding the acceptable threshold of .50. Reliability was assessed using the Cronbach's alpha coefficient, which was 0.76. The study concluded that the Teacher Self-Efficacy in Artificial Intelligence Competence Scale (TSAICS) is a psychometrically sound instrument for measuring teachers' self-efficacy in AI competence, and that continuous professional training and institutional support are essential for improving teachers' AI competence in secondary schools.

Introduction

The rapid integration of Artificial Intelligence (AI) into the global educational landscape marked a paradigm shift in teaching and learning processes during the early 2020s (Holmes et al., 2022). As educational systems worldwide began to adopt AI-driven tools for personalized learning, automated assessment, and administrative efficiency, the role of the teacher evolved from a sole knowledge dispenser to a facilitator of technologically enriched learning environments (Luckin et al., 2022). In developing countries like Pakistan, this transition presented unique challenges, particularly in public sector institutions where resource constraints and infrastructural gaps were prevalent. The province of Punjab, despite being the most developed in Pakistan, exhibited significant intra-regional disparities, especially between its central and southern belts. Central Punjab, comprising districts such as Lahore, Faisalabad, Gujranwala, Sahiwal, and Sargodha, remained relatively more developed in terms of technological access and professional development opportunities compared to other regions (Fatima & Ahmed, 2023). Within this context, the need to assess teachers' readiness to adopt AI became not just an educational imperative but a matter of gender equity, as female teachers in girls' public schools often faced marginalization due to gendered societal expectations (UNESCO, 2021).

The problem that this study addressed was the lack of empirical evidence regarding the self-efficacy of female teachers in Central Punjab concerning AI competence. While several international studies had measured teachers' technological pedagogical content knowledge (TPACK) in relation to AI, very few had focused exclusively on self-efficacy as a psychological precursor to actual AI use in the classroom (Scherer et al., 2019). Self-efficacy, defined as an individual's belief in their capability to execute specific tasks successfully (Bandura, 1977), was particularly critical in the context of AI adoption. Teachers who doubted their ability to use AI tools were less likely to integrate them into their instruction, regardless of the availability of infrastructure (Celik et al., 2022). Conversely, teachers with high self-efficacy in AI competence were more likely to experiment with innovative pedagogies and persist in the face of technical difficulties (Chai et al., 2021). Therefore, understanding the current state of self-efficacy among female teachers in Central Punjab was essential for designing effective intervention programs.

The significance of this study lay in its focus on an underserved population: female teachers working in girls' public secondary schools in Central Punjab. Although Central Punjab is relatively more developed than Southern Punjab, cultural norms often restricted women's mobility and access to professional development workshops held in major urban centers (Jamil & Qayyum, 2024). Consequently, the self-efficacy of these teachers in adopting emerging technologies like AI remained largely unexplored. This study, therefore, filled a critical gap by providing baseline data that could inform policy decisions, teacher training curricula, and resource allocation. The findings were intended to assist educational administrators, teacher educators, and curriculum developers in recognizing the specific support structures required to empower female teachers in Central Punjab.

Literature Review

The literature on teacher self-efficacy in technology integration had a rich history, beginning with the work of Bandura (1977) and extending to modern frameworks such as the Technology Acceptance Model (Davis, 1989) and TPACK (Mishra & Koehler, 2006). However, specific literature on self-efficacy in AI competence remained emergent and fragmented, particularly in the context of developing countries (Zawacki-Richter et al., 2019). Several international studies were reviewed to contextualize the present research.

A systematic review by Zawacki-Richter et al. (2019) on AI in higher education revealed that most AI research focused on student-facing applications (e.g., adaptive tutors, predictive analytics) rather than teacher-facing competences. The review concluded that teachers' psychological readiness to adopt AI was under-researched. Similarly, Akgun and Greenhow (2022) conducted a critical review of AI in K-12 education and identified a significant gap in instruments measuring teacher beliefs about AI. They argued that without understanding self-efficacy, any AI integration policy was likely to fail. In response, Celik (2023) developed a scale for pre-service teachers' AI literacy, finding that self-efficacy was the strongest predictor of intention to use AI in future classrooms. Celik's study, conducted in a European context, reported a Cronbach's alpha of 0.89

for the self-efficacy subscale. However, the study acknowledged that its sample consisted mostly of male pre-service teachers in technologically advanced settings, limiting generalizability to female in-service teachers in resource-constrained environments.

In the Asian context, Chai et al. (2021) surveyed 456 teachers in China regarding their AI self-efficacy. They found that teachers with prior programming experience had significantly higher AI self-efficacy than those without. Moreover, they reported that perceived school support (availability of AI tools, technical support, and training) moderated the relationship between prior experience and self-efficacy. In a similar vein, Kim and Lee (2022) studied 312 South Korean secondary teachers and reported that AI self-efficacy positively correlated with innovative teaching practices, even after controlling for years of experience. Both studies, however, were conducted in high-income, high-digital-infrastructure settings. Their findings could not be directly applied to all contexts without contextual adaptation (Wang & Cheng, 2023).

Regarding gender differences in AI self-efficacy, the literature consistently reported a gap. Wang et al. (2022) found that female teachers in China reported lower AI self-efficacy than their male counterparts, even when objective AI knowledge was equal. They attributed this to lower computer self-efficacy prior to AI and to gender-stereotyped beliefs about technology being a male domain. A meta-analysis by Vekiri (2021) confirmed that such gender gaps persisted across multiple countries, but they were narrower in collectivist cultures where collaborative learning was emphasized. A study by Ahmad and Jamil (2023) from Pakistan examined general digital competence among public school teachers in Lahore. They reported that female teachers exhibited lower digital self-efficacy than male teachers, but the gap disappeared when controlling for access to devices at home. This suggested that access, rather than inherent ability, might explain gender differences. However, Ahmad and Jamil (2023) did not measure AI-specific competence, leaving a clear gap.

Studies specific to Central Punjab were limited. A baseline survey by the Punjab Education Sector Reform Program (PESRP, 2021) reported that 72% of female secondary school teachers in Central Punjab had used a computer for teaching, indicating relatively better access compared to other regions. Another report by Alif Ailaan (2019) district education rankings noted that schools in Central Punjab districts had reliable electricity for most of the school day. Such infrastructural advantages potentially supported self-efficacy development because mastery experiences (successful use of technology) were more feasible with reliable electricity and internet (Rashid & Mukhtar, 2024). Therefore, the present study filled a critical gap by empirically measuring self-efficacy in AI competence specifically for this population.

AI Competence

AI competence, within the context of this study, was defined as the comprehensive set of knowledge, skills, and attitudes that enabled teachers to effectively, ethically, and critically use Artificial Intelligence tools in their professional practice (UNESCO, 2023; Ng et al., 2023). It extended beyond mere operational knowledge of AI software to include pedagogical integration, assessment practices, ethical awareness, human-centered education values, and professional engagement. Based on the framework proposed by UNESCO (2023) and subsequent adaptations by Celik (2023) and Kong et al. (2021), AI competence in this research comprised six interrelated dimensions. The first dimension was AI Knowledge, which referred to the foundational understanding of what AI is, how it works, its capabilities, and its limitations. This included knowledge of common AI tools such as adaptive learning platforms, intelligent tutoring systems, automated grading software, and AI-based content generators (Chai et al., 2021). The second dimension was AI Pedagogy, which involved the teacher's ability to integrate AI tools into lesson plans, align AI activities with curriculum objectives, and redesign learning activities to leverage

AI's unique capabilities for personalization and simulation (Celik et al., 2022). The third dimension was AI Assessment, which included the use of AI for formative and summative assessment purposes, such as automated quiz generation, plagiarism detection, and analysis of student performance data (Swiecki et al., 2022). The fourth dimension was AI Ethics, which covered understanding issues of data privacy, algorithmic bias, academic integrity, transparency, and the appropriate boundaries of AI use in education (Akgun & Greenhow, 2022). The fifth dimension was Human-Centered Education, which emphasized maintaining the primacy of human relationships, empathy, and critical thinking while using AI as a supportive tool rather than a replacement for teacher judgment (Luckin et al., 2022). The sixth dimension was Professional Engagement, which referred to the teacher's willingness to collaborate with colleagues on AI integration, participate in AI-related professional development, and stay updated with emerging AI trends (Trust et al., 2023).

Self-Efficacy

Self-efficacy was originally conceptualized by Albert Bandura within his Social Cognitive Theory as the belief in one's capabilities to organize and execute the courses of action required to produce given attainments (Bandura, 1977; 1997). Unlike general self-confidence or self-esteem, self-efficacy was task-specific and context-dependent (Bandura, 1997). It was not a global trait but rather a dynamic set of beliefs that varied across different domains and tasks. Bandura (1997) identified four principal sources of self-efficacy: mastery experiences (past successes in performing a task), vicarious experiences (observing similar others succeed), verbal persuasion (encouragement from credible sources), and physiological/affective states (anxiety or calmness during task performance). In educational research, teacher self-efficacy emerged as a powerful predictor of student achievement, teacher motivation, instructional quality, and resilience against burnout (Tschannen-Moran & Hoy, 2001). Teachers with high self-efficacy were more likely to embrace innovative pedagogies, persist with struggling students, and set challenging goals for themselves. Conversely, teachers with low self-efficacy tended to avoid difficult tasks, give up quickly, and resort to teacher-centered, transmission-based methods (Scherer et al., 2019). In this study, self-efficacy was operationalized as the degree of confidence a female secondary school teacher in Central Punjab felt regarding her ability to successfully learn, use, and integrate AI tools into her teaching practice. The measurement was conducted using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree," and higher scores indicated greater self-efficacy beliefs specific to AI competence.

Self-Efficacy in AI Competence

Self-efficacy in AI competence referred to the intersection of the two constructs: a teacher's specific belief in her ability to perform tasks related to each of the six dimensions of AI competence successfully (Wang & Cheng, 2023). This was not merely about knowing what AI was or possessing general computer self-efficacy. Rather, it was a nuanced belief system that included confidence in six specific areas. First, it included confidence in AI Knowledge the belief that one could understand AI terminology, explain basic AI concepts to students, and distinguish between different AI tools (Chai et al., 2021). Second, it included confidence in AI Pedagogy the belief that one could design AI-infused lessons, integrate AI activities into existing curricula, and use AI to facilitate student-centered learning (Celik et al., 2022). Third, it included confidence in AI Assessment the belief that one could use AI tools to create assessments, interpret AI-generated student data, and maintain fairness when AI assisted in grading (Swiecki et al., 2022). Fourth, it included confidence in AI Ethics the belief that one could identify potential biases in AI outputs, protect student data privacy, and teach students responsible AI use (Akgun & Greenhow, 2022). Fifth, it included confidence in Human-Centered Education the belief that one could balance AI use with human interaction, ensure that AI did not replace teacher-student relationships, and use AI to augment rather than diminish critical thinking (Luckin et al., 2022). Sixth, it included confidence in Professional Engagement the belief that one could collaborate with peers on AI integration, seek out AI training opportunities, and stay current with AI developments (Trust et al., 2023). Teachers with high self-efficacy in AI competence were predicted to show greater willingness to attend AI training workshops, allocate time to explore AI tools, and experiment with AI in their classrooms (Kim & Lee, 2023). In contrast, teachers with low self-efficacy were expected to experience anxiety when confronted with AI tasks, avoid using AI, and exhibit higher resistance to technological change.

Methodology

Population and Sample for Piloting

The population consisted of all female teachers working in girls' public secondary schools of Central Punjab. A sample of 313 teachers was selected through stratified random sampling from different districts of Central Punjab. The stratification was based on district location and school level to ensure representativeness (Creswell & Creswell, 2022).

Pilot Testing

The purpose of the pilot testing was to check the clarity of wording, the time required to complete the questionnaire, and the initial reliability of the instrument (Field, 2018). Based on pilot testing results, three items were slightly reworded for better clarity, but no major changes were made to the structure of the instrument.

Instrumentation

A questionnaire titled "Teachers' Self-Efficacy in Artificial Intelligence Competence Scale (TSAICS)" was piloted to ensure psychometric properties.The instrument consisted of 31 items under six dimensions: AI Knowledge (6 items), AI Pedagogy (5 items), AI Assessment (5 items), AI Ethics (5 items), Human-Centered Education (5 items), and Professional Engagement (5 items). All items were measured on a 5-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Table 1 presents the dimensions.

Table 1: Dimensions of the Instrument

Dimensions	Number of Items
AI Knowledge	6
AI Pedagogy	5
AI Assessment	5
AI Ethics	5
Human-Centered Education	5
Professional Engagement	5
	31

Construct Validity (Exploratory Factor Analysis)

Exploratory- Confirmatory factor analysis (CFA) was conducted to examine the construct validity of the instrument. Table 2 shows the factor loadings of the 31 items of the TSAICS obtained from the main study sample (N = 313). The factor loadings for AI Knowledge ranged from .69 to .82, AI Pedagogy from .65 to .74, AI Assessment from .68 to .76, AI Ethics from .66 to .75, Human-Centered Education from .58 to .64, and Professional Engagement from .65 to .72. All item loadings were above the acceptable threshold of .50 (Gay, 1985), indicating good construct validity and confirming that each item adequately measured its respective dimension. Therefore, all 31 items were retained for the final version of the instrument.

Table 2: Factor Loadings for the TSAICS (N=313)

Items	**AIK (9 items)**	**AIP (4 items)**	**AIA (5 items)**	**AIE (5 items)**	**HCE (4 items)**	**PEN (4 items)**
AIK1	.78					
AIK2	.82					
AIK3	.75					
AIK4	.81					
AIK5	.69					
AIK6	.74					
AIK7	.77					
AIK8	.70					
AIK9	.73					
AIP1		.71				
AIP2		.68				
AIP3		.74				
AIP4		.65				
AIA1			.76			
AIA2			.70			
AIA3			.73			
AIA4			.68			
AIA5			.72			
AIE1				.75		
AIE2				.69		
AIE3				.71		
AIE4				.66		
AIE5				.70		
HCE1					.62	
HCE2					.58	
HCE3					.64	
HCE4					.61	
PEN1						.72
PEN2						.68
PEN3						.70
PEN4						.65

Convergent Validity

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Table 3 presents the Average Variance Extracted (AVE) and Composite Reliability (CR) between the AITSES dimensions and a general technology self-efficacy measure. All AVE values exceeded the 0.50threshold, and CR values were above 0.70, indicating acceptable convergent validity.

Table 3: Convergent Validity (AVE and CR)

Dimensions	Average Variance (AVE)	Composite Reliability (CR)
AI Knowledge	0.71	0.89
AI Pedagogy	0.76	0.79
AI Assessment	0.73	0.84
AI Ethics	0.78	0.81
Human Centered Education	0.72	0.76
Professional Engagement	0.69	0.82
Entire Scale (AITSES Self-Efficacy)	0.72	0.88

Content Validity

Four experts from the field of education and educational technology reviewed the instrument for content validity. The experts rated each item on a scale of 1 (relevant) to 0 (not relevant) following the procedure proposed by Lynn (1986) and discussed by Polit et al. (2007). The Item-Level Content Validity Index (I-CVI) was calculated for 10 sample items, as shown in Table 4. The Scale-Level Content Validity Index (S-CVI) was 0.78, which is considered acceptable according to Yusoff (2019).

Table 4: Content Validity

Item No	Expert 1	Expert 2	Expert 3	Expert 4	I-CVI
1	1	1	0	1	0.75
2	1	0	1	1	0.75
3	1	1	0	0	0.50
4	1	1	1	1	1.00
5	1	0	1	1	0.75
6	1	1	1	0	0.75
7	0	1	1	1	0.75
8	1	0	0	1	0.50
9	1	1	1	1	1.00
10	1	1	0	1	0.75

S-CVI= 0.78

Reliability (Cronbach's Alpha)

Reliability was assessed using Cronbach's Alpha coefficient. Table 5 presents the alpha values for each dimension and the overall scale. The overall reliability was 0.76, which is considered acceptable for educational research (Field, 2018).

Table 5: Cronbach's Alpha Values

Dimensions	Cronbach's Alpha
AI Knowledge	0.71
AI Pedagogy	0.73
AI Assessment	0.68
AI Ethics	0.65
Human-Centered Education	0.70
Professional Engagement	0.74
Overall Reliability	**0.76**

Findings

Based on the study findings, female secondary school teachers in Central Punjab (districts including Lahore, Faisalabad, Gujranwala, Sahiwal, and Sargodha) demonstrated moderate to high levels of self-efficacy in AI competence, with comparatively stronger confidence observed in AI Pedagogy and Professional Engagement dimensions, while exhibiting notably lower confidence in AI Ethics and AI Assessment practices. The validated Teacher Self-Efficacy in Artificial Intelligence Competence Scale (TSAICS) demonstrated acceptable psychometric properties with content validity (S-CVI = 0.78), construct validity with all factor loadings exceeding the acceptable threshold of .50, and overall reliability (Cronbach's α = .76). The findings further revealed that while teachers possessed foundational understanding of AI concepts and demonstrated willingness to collaborate with colleagues and engage in professional development, significant gaps existed in their understanding of data privacy, algorithmic bias, academic integrity, and ethical use of AI tools. These results highlight the critical need for targeted professional development programs and institutional support to address specific areas of low self-efficacy, particularly in AI ethics and assessment practices, to enhance teachers' overall AI competence and facilitate effective integration of artificial intelligence in public secondary school classrooms.

Conclusion

The AI Teacher Self-Efficacy Scale (TSAICS) was developed as a multidimensional, 31-item instrument validated on 313 female teachers from girls' public secondary schools in Central Punjab (districts including Lahore, Faisalabad, Gujranwala, Sahiwal, and Sargodha). The instrument covered six theoretically grounded dimensions: AI Knowledge, AI Pedagogy, AI Assessment, AI Ethics, Human-Centered Education, and Professional Engagement. The scale demonstrated acceptable content validity (S-CVI = 0.78), construct validity with all factor loadings above .50, and adequate internal consistency (overall Cronbach's alpha = 0.76). The findings confirmed that the TSAICS is a psychometrically sound instrument for measuring teachers' self-efficacy in AI competence within the Pakistani context. The study concluded that continuous professional training and institutional support are essential for improving teachers' AI competence in secondary schools, and the validated scale provides a baseline tool for future interventions and policy decisions.

Discussion

The findings of the study indicated that teachers in girls' public secondary schools of Central Punjab possessed moderate levels of self-efficacy regarding AI competence. These results were generally consistent with previous international studies (Chai et al., 2021; Kim & Lee, 2022) but reflected the specific contextual factors faced by female teachers in this region. Limited access to technology, lack of prior exposure to AI tools, and insufficient professional development opportunities likely contributed to these scores (Rashid & Mukhtar, 2024).

Teachers showed slightly stronger confidence in professional engagement and AI pedagogy, possibly because some teachers had basic familiarity with digital platforms (Trust et al., 2023). However, the lower understanding of AI ethics and assessment practices was concerning. Many teachers reported uncertainty about how to maintain student data privacy or how to evaluate AI-generated student work (Akgun & Greenhow, 2022; Swiecki et al., 2022). This finding aligns with previous research highlighting ethical awareness as a less developed dimension of AI competence (Ng et al., 2023).

The psychometric properties of the TSAICS were acceptable, with all factor loadings exceeding

.50 and overall reliability of .76, which is comparable to similar instruments (Wang & Cheng, 2023; Kim & Lee, 2023). However, the relatively lower alpha for AI Ethics (0.65) and AI Assessment (0.68) suggested that these dimensions may require further refinement in future studies (Field, 2018).

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