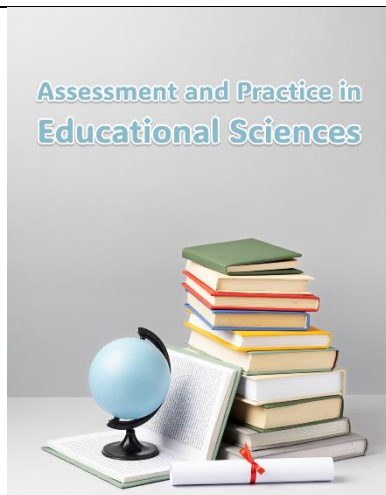




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Development and Psychometric Validation of an Instrument for Assessing the Quality of Teachers' In-Service Training

ABSTRACT

This study aimed to develop and psychometrically validate an instrument for assessing the quality of teachers' in-service training programs. A mixed-methods approach (qualitative–quantitative) was employed, integrating in-depth qualitative data with quantitative evidence. In the qualitative phase, semi-structured interviews were conducted with teachers, school principals, and education experts to identify components, categories, and interrelationships within in-service training programs. Based on these findings, a 30-item questionnaire was developed and administered to 384 participants to evaluate the instrument's validity and reliability. First-order factor analysis revealed item factor loadings ranging from 0.58 to 1.00, while second-order factor analysis indicated loadings for the main dimensions between 0.98 and 1.10, demonstrating high explanatory power and structural validity. The ten main dimensions—Smart Professional Needs Assessment, Advanced Pedagogical Design, Smart Digital Learning, Innovative Smart Methods, Sustainable Professional Development, Smart Educational Evaluation, Learning Organizational Support, Networked Professional Collaboration, Educational Digital Inclusion, and AI Literacy in Education—played the most significant role in explaining the quality of in-service training. Results further confirmed strong convergent and discriminant validity, with high internal consistency ($\alpha=0.958\text{--}0.996$, AVE=0.921–0.996). Findings suggest that the instrument can comprehensively evaluate multiple aspects of in-service training and identify key indicators affecting program quality, such as self-directed learning and the integration of digital and AI-based educational technologies. Overall, this study demonstrates that the developed instrument provides a valid, reliable, and systematic framework for assessing the effectiveness of in-service teacher training and offers practical applications for educational managers and policymakers in designing, implementing, and monitoring these programs.

Keywords: Advanced Pedagogical Design, AI Literacy in Education, In-Service Teacher Training, Smart Educational Evaluation

Introduction

The quality of an educational system is closely connected to the knowledge, competencies, adaptability, and professional commitment of its teachers. Although initial teacher education establishes the foundational knowledge and skills required for entering the profession, it cannot adequately prepare teachers for every pedagogical, technological, social, and organizational change they will encounter throughout their careers. Teaching is a dynamic profession in which instructional methods,

curricula, assessment practices, learner characteristics, educational technologies, and policy expectations continually evolve. Consequently, teachers require sustained opportunities to update their professional knowledge, reflect on their classroom practices, acquire emerging competencies, and respond effectively to changing educational environments. In-service teacher training is therefore regarded as a central mechanism for maintaining teacher competence and promoting continuous professional development. Evidence indicates that well-designed in-service training can strengthen teachers' pedagogical knowledge, professional confidence, classroom performance, and capacity to address students' diverse learning needs. It can also create opportunities for teachers to exchange experiences, reconsider established practices, and integrate new approaches into their instructional activities. Accordingly, in-service education should not be viewed as an occasional administrative requirement but as an integral component of teachers' career-long learning and the continuous improvement of educational quality (1, 2).

The growing importance of in-service training is partly related to the increasing complexity of teachers' professional roles. Contemporary teachers are expected not only to transmit subject knowledge but also to facilitate active learning, manage heterogeneous classrooms, use formative and summative assessment effectively, promote students' social and emotional development, and employ digital resources responsibly. They must respond to cultural and linguistic diversity, address differences in students' abilities and backgrounds, collaborate with colleagues and families, and participate in school-level improvement processes. These responsibilities require professional development programs that move beyond the passive presentation of theoretical information and instead provide practical, participatory, reflective, and context-sensitive learning experiences. Research on English-language teachers has particularly emphasized that conventional, short-term, and lecture-oriented courses frequently fail to produce meaningful professional change because they are insufficiently connected to teachers' actual classroom challenges. Effective programs should be based on identified professional needs, involve teachers actively in the learning process, and provide opportunities for practice, feedback, reflection, and follow-up support. Thus, the effectiveness of in-service training depends not merely on whether courses are offered but on whether their content, instructional processes, and expected outcomes correspond to teachers' professional realities and developmental needs (3, 4).

In-service training may positively influence professional growth when it is relevant, sustained, and appropriately implemented. Teachers can use such programs to update subject-matter knowledge, improve lesson planning, strengthen classroom management, adopt more learner-centered methods, and become familiar with innovative evaluation strategies. Participation in meaningful training may additionally enhance professional motivation, self-efficacy, collegial interaction, and willingness to undertake instructional innovation. However, these outcomes cannot be assumed to result automatically from attendance. Training programs vary considerably in their objectives, duration, instructional quality, accessibility, organizational support, and alignment with teachers' needs. Some programs generate authentic professional learning, whereas others are perceived as repetitive, disconnected from practice, or primarily designed to satisfy administrative regulations. The distinction between productive and unproductive training is therefore fundamentally a question of quality. Research examining obligatory professional training has shown that teachers' judgments about whether training represents worthwhile professional investment or wasted time are shaped by its relevance, intellectual value, practical applicability, and responsiveness to their experiences. Consequently, evaluating course participation rates or completion certificates alone cannot reveal whether a program has contributed to professional learning or improved teaching practice (1, 5).

The quality of in-service training is a multidimensional construct encompassing the entire cycle of professional development, from needs assessment and policy formulation to instructional design, implementation, evaluation, and post-training support. At the planning stage, training should be grounded in systematic analyses of teachers' competency gaps, workplace demands, learner needs, curriculum changes, and anticipated professional requirements. At the design stage, course

objectives, content, instructional activities, and assessment procedures must be internally coherent and consistent with adult-learning principles. During implementation, trainers' competence, participant engagement, opportunities for interaction, access to resources, organizational conditions, and the practical relevance of learning activities become especially important. Finally, evaluation should determine not only participant satisfaction but also knowledge acquisition, behavioral change, transfer of learning to classroom practice, and potential effects on educational outcomes. Studies addressing the quality of language-teacher development have indicated that weaknesses in planning, facilitation, resources, follow-up mechanisms, and institutional coordination can substantially reduce the value of in-service programs. Therefore, quality assessment requires a comprehensive framework capable of examining interconnected structural, pedagogical, managerial, and outcome-related dimensions rather than relying on a single indicator of effectiveness (6, 7).

Policy and organizational conditions are also decisive in determining whether in-service training achieves its intended purposes. Even a theoretically sound course may have limited impact when implementation policies are unclear, funding is inadequate, participation opportunities are unequal, or teachers are not provided with sufficient time and institutional support. The translation of professional-development policies into effective practice requires coordination among ministries, local education authorities, schools, training institutions, administrators, trainers, and teachers. Implementation problems may arise when training programs are designed centrally without sufficient attention to local conditions, when course selection is unrelated to teachers' actual responsibilities, or when participation is motivated primarily by promotion requirements and formal credits. Assessments of in-service training policies have revealed that discrepancies may exist between stated policy objectives and the practical experiences of teachers in schools. Such discrepancies demonstrate that program quality is influenced by governance, resource allocation, monitoring, accountability, and organizational readiness. A valid evaluation framework must therefore address not only the instructional content of courses but also the institutional environment that supports or constrains teacher participation, learning transfer, and sustained professional improvement (7, 8).

The diversification of student populations has further expanded the scope of competencies that should be addressed through professional development. Teachers increasingly work in classrooms characterized by cultural, linguistic, socioeconomic, and educational differences, requiring them to adopt inclusive and culturally responsive practices. Professional development for multicultural education should enable teachers to critically examine assumptions, recognize diverse learner identities, design equitable learning experiences, and manage communication across cultural differences. Blended training models can be especially useful in this context because they combine the interpersonal and collaborative benefits of face-to-face learning with the flexibility and accessibility of online environments. Nevertheless, the effectiveness of blended programs depends on coherent instructional design, active participation, meaningful collaboration, appropriate technological support, and opportunities to apply new understandings in authentic professional settings. Lessons derived from blended multicultural teacher training reinforce the proposition that program quality cannot be reduced to content coverage. It also includes the suitability of delivery methods, the quality of interaction, the inclusiveness of learning environments, and the extent to which training contributes to observable changes in teachers' professional understanding and practice (9).

Digital transformation has introduced another essential dimension into the evaluation of in-service teacher training. Online platforms, cloud computing, learning-management systems, virtual classrooms, digital content repositories, and collaborative applications can extend training beyond the constraints of time and location. These technologies make it possible to personalize learning, provide continuous access to resources, support peer interaction, document learning progress, and connect teachers across schools and regions. Cloud-based training environments may also facilitate flexible course delivery, centralized content management, data-informed monitoring, and the integration of synchronous and asynchronous learning activities. However, the availability of technology does not itself guarantee meaningful professional development. Poorly designed digital courses

may reproduce the limitations of traditional lecture-based instruction, while inadequate infrastructure, limited digital competence, restricted connectivity, and unequal access can exclude some participants. The quality of technology-supported in-service training must therefore be assessed in relation to usability, pedagogical coherence, learner engagement, accessibility, technical support, data security, and alignment with professional needs. Models developed for cloud-based in-service education illustrate the importance of validating both the conceptual structure and practical functionality of emerging training systems (10).

Artificial intelligence is now creating additional opportunities and challenges for teacher education. AI-supported systems can assist in identifying professional learning needs, recommending individualized learning pathways, generating instructional resources, simulating classroom situations, providing automated feedback, and analyzing participation and performance data. These applications may make in-service education more adaptive, responsive, and scalable. AI can also help teachers develop competencies relevant to contemporary classrooms, including the critical evaluation of generated content, responsible use of educational data, and integration of intelligent tools into lesson planning, instruction, and assessment. At the same time, the adoption of AI raises concerns regarding algorithmic bias, privacy, transparency, accuracy, academic integrity, and the possibility of overreliance on automated systems. High-quality in-service training must consequently address both the practical applications and ethical implications of artificial intelligence. Teacher AI literacy should include conceptual understanding, critical judgment, pedagogical application, data awareness, and ethical responsibility. Thus, instruments designed to assess contemporary professional-development programs must incorporate digital learning and AI literacy rather than relying exclusively on dimensions developed for conventional training environments (11).

Another defining feature of high-quality professional development is the extent to which it promotes sustained, collaborative, and self-directed learning. Teachers' professional growth rarely occurs through isolated courses alone; instead, it develops through repeated cycles of learning, application, reflection, feedback, and revision. Professional learning communities, peer networks, mentoring, coaching, collaborative inquiry, and experience sharing can help teachers interpret new knowledge and adapt it to their specific classroom contexts. Assessment practices within training programs can also support learning when they encourage reflection, dialogue, and constructive feedback. Peer grading, for example, may enable teachers to examine colleagues' work, clarify professional standards, and develop evaluative judgment, but its usefulness depends on the validity and reliability of the assessment process. Research on peer-grading in in-service teacher training demonstrates that evaluation approaches themselves must be empirically examined before they are used to draw conclusions about participant performance. This reinforces the need for training-quality instruments that assess the credibility of evaluation procedures, the quality of feedback, and opportunities for professional collaboration alongside more conventional dimensions such as course content and trainer performance (2, 12).

The evaluation of in-service training has often focused on immediate participant satisfaction, perceived usefulness, or self-reported learning. Although these indicators provide valuable information, they offer only a partial representation of program quality. Participants may report satisfaction with an enjoyable course even when it produces limited professional change, while a cognitively demanding program may initially receive more critical evaluations despite generating substantial learning. Comprehensive assessment should therefore consider the appropriateness of needs assessment, relevance of content, quality of pedagogical design, competence of trainers, participant engagement, adequacy of resources, organizational support, learning outcomes, transfer to the workplace, and sustainability of professional development. Studies assessing in-service courses in organizational settings have similarly emphasized the relationship between training and the improvement of employees' professional skills. Such research suggests that the success of training should be judged against clear competency-based outcomes and organizational expectations rather than attendance alone. Nevertheless, the coexistence of similar studies and

differently reported versions of training-success assessments also highlights the need for conceptually clear constructs and standardized measurement procedures (13, 14).

Measurement is central to evidence-based improvement because educational managers cannot systematically enhance dimensions of quality that have not been clearly defined and reliably assessed. A useful quality-assessment instrument should possess a strong theoretical foundation, reflect the lived experiences of relevant stakeholders, and demonstrate satisfactory psychometric properties. Item development should be grounded in a comprehensive conceptualization of the construct, while validation should establish whether the proposed dimensions are empirically distinguishable and consistently measured. Face and content validity can determine whether items are understandable, relevant, and representative, whereas construct validity can examine whether the internal structure of the instrument corresponds to the intended theoretical framework. Reliability analyses are required to establish the consistency of scores, and convergent and discriminant evidence can clarify whether related indicators share sufficient variance while remaining distinguishable from other constructs. Without such evidence, evaluation results may reflect measurement error, incomplete construct coverage, or context-specific assumptions rather than the actual quality of training programs. The development of validated models and assessment processes is therefore necessary for producing defensible judgments and guiding program improvement (10, 12).

Existing research provides important evidence regarding professional growth, teacher learning, policy implementation, digital delivery, multicultural education, AI integration, and organizational skill development. However, much of this evidence concentrates on individual aspects of in-service training, particular groups of teachers, specific subject areas, or selected program outcomes. Studies of English-language teachers, for example, provide detailed insights into pedagogical relevance and professional support, but instruments developed in such contexts may not fully represent the broader responsibilities of teachers across educational levels and disciplines. Similarly, policy evaluations may identify implementation deficiencies without providing a sufficiently detailed tool for assessing instructional quality, while technology-oriented models may emphasize infrastructure and delivery but devote less attention to organizational culture, professional collaboration, inclusion, or ethical competence. The multidimensional nature of contemporary teacher development therefore creates a need for an integrated instrument encompassing professional needs assessment, advanced pedagogical design, digital learning, innovative instructional methods, sustainable professional growth, educational evaluation, organizational support, networked collaboration, digital inclusion, and AI literacy (4, 6, 9, 11).

The absence of a comprehensive and psychometrically supported instrument has important practical consequences. Educational authorities may allocate substantial resources to programs without being able to determine which components are effective, which require revision, and which institutional barriers prevent learning transfer. Program designers may rely on participant satisfaction while overlooking needs assessment, inclusiveness, technological accessibility, organizational support, and sustainable changes in professional behavior. Furthermore, comparisons among courses, schools, regions, and participant groups remain difficult when evaluation criteria are inconsistent. A multidimensional instrument can provide a shared framework for diagnosing strengths and weaknesses, setting quality standards, monitoring implementation, comparing alternative training models, and supporting evidence-based policy decisions. Such an instrument should be sufficiently comprehensive to reflect emerging educational realities while remaining clear and practical for use by teachers, school administrators, university faculty members, program evaluators, and policymakers. By integrating qualitative stakeholder perspectives with quantitative psychometric testing, instrument development can connect contextual relevance with scientific measurement and produce an evaluative framework that is both locally meaningful and methodologically defensible (5, 7, 8).

Accordingly, the aim of this study was to develop and psychometrically validate a comprehensive instrument for assessing the quality of teachers' in-service training programs.

Methods and Materials

Study Design

The present study was designed as a mixed-methods study (qualitative–quantitative) aimed at developing and validating a tool for assessing the quality of in-service teacher training. This approach allowed the integration of in-depth qualitative data with empirical quantitative evidence to examine the conceptual model of in-service teacher training from both scientific and practical perspectives. The qualitative phase employed the grounded theory method and semi-structured interviews to identify components, categories, and relationships among them. The quantitative phase involved designing a researcher-made questionnaire based on the qualitative findings and analyzing the data using structural equation modeling (SEM).

Population and Sample

The qualitative study population included teachers, school principals, and experts in the field of education, who could provide valuable insights due to their practical and specialized experience in in-service training. The qualitative sample size was determined based on conceptual saturation, and interviews continued until the twenty-first participant to ensure data adequacy.

The quantitative study population comprised teachers, school principals, and university faculty members with practical or research experience related to in-service training. In the quantitative phase of the study, the sample size was determined based on the principles of Structural Equation Modeling (SEM) and the need for precise estimates. Research indicates that a minimum of 200 observations is required to ensure stable coefficients, explanatory power, and model fit, and that 5 to 10 observations per observed variable are recommended. Considering the 30 observed variables in the questionnaire, an appropriate sample size would range between 150 and 300 participants. However, to increase accuracy, reduce sampling error, cover geographic diversity, and enhance generalizability, a total of 384 participants were selected. According to the Krejcie and Morgan standard table, this number provides a reliable representation of a large population and allows for advanced analyses, as well as the assessment of the reliability, validity, and overall validation of the teachers' in-service training model.

In the qualitative phase, non-probability purposive sampling was used to identify participants with relevant experience and expertise. In the quantitative phase, a multistage sampling method, including cluster and stratified random sampling, was employed to cover geographic, professional, and organizational diversity within the population.

Data Collection Instruments

In the qualitative phase, data were collected through semi-structured interviews and analysis of educational documents. For the quantitative phase, a researcher-made questionnaire consisting of 30 items derived from qualitative findings was developed, using a five-point Likert scale. The initial version of the questionnaire was reviewed by experts and piloted, resulting in a final validated version.

Validity and Reliability

For the qualitative phase, credibility, transferability, dependability, and confirmability criteria were applied, and inter-coder agreement was measured using Cohen's kappa coefficient of 0.850. In the quantitative phase, the questionnaire's validity was assessed through face, content, and construct validity, including convergent and discriminant validity. Reliability was evaluated using Cronbach's alpha, composite reliability, and internal consistency.

Data Analysis Method

Qualitative data were analyzed using the grounded theory approach through open, axial, and selective coding to extract key components and categories. Quantitative data were analyzed using SPSS, SmartPLS, and AMOS. Prerequisites for factor analysis, including the Kaiser–Meyer–Olkin (KMO) test and Bartlett’s test of sphericity, were assessed, followed by first- and second-order confirmatory factor analysis and structural equation modeling. Model fit indices, including RMSEA, CFI, TLI, and SRMR, were evaluated.

Findings and Results

During the open coding process, an initial set of 90 concepts was identified. In the second stage of open or focused coding, following preliminary operations, semantically similar concepts were classified into 30 major categories. During the axial coding stage, 10 core categories were extracted. Furthermore, in the selective coding stage, the major and core categories were organized into three primary groups: conditional (including causal conditions, intervening conditions, and contextual conditions), strategic, interactive, and outcome-related. The category “Intelligent Management of In-Service Teacher Training” was selected as the final core category.

In summary, through the grounded theory-based analysis process, 30 major categories and 10 core categories were obtained, which subsequently formed the framework for the subscales and scales of the tool for assessing the quality of in-service teacher training. These scales were then used for the development and psychometric validation of the instrument. Table 1 presents the in-service teacher training quality assessment tool along with the factor loadings of each item in the first-order confirmatory factor analysis.

Table 1. Measurement Tool for the Quality of In-Service Teacher Training Programs with Factor Loadings for Each Item

No.	Question	Factor Loading	Result
1	In in-service training programs, "teachers' skill gap analysis" is effectively conducted and their professional competencies and deficiencies are identified.	0.98	Confirmed (>0.30)
2	In course design, "data-based educational prioritization" is applied so that educational resources are allocated to more effective activities.	0.97	Confirmed (>0.30)
3	"Predicting teachers' future professional needs" is conducted in educational planning and courses are aligned with technological changes and emerging needs.	0.94	Confirmed (>0.30)
4	"Adult learning-based instructional design" is observed in courses and programs are shaped according to teachers' experience, motivation, and learning style.	0.89	Confirmed (>0.30)
5	"Strengthening teachers' self-directed learning" is reinforced in programs, providing opportunities for independent, continuous, and purposeful professional skill development.	1.00	Confirmed (>0.30)
6	"Interactive educational structure" is created in courses, providing a collaborative environment based on interaction between teachers and instructors.	0.58	Confirmed (>0.30)
7	"Digital education infrastructure" including technological tools, online access, and content management is effectively provided in courses.	0.90	Confirmed (>0.30)
8	"AI-based personalized learning" is implemented in courses and each teacher's learning path is customized according to their needs, pace, and individual style.	0.99	Confirmed (>0.30)
9	"Interactive virtual training" is implemented in programs, creating an engaging, collaborative, and practical learning experience for teachers.	0.98	Confirmed (>0.30)
10	"Blended learning implementation" including in-person and online training enhances teachers' learning and facilitates effective access and interaction.	0.92	Confirmed (>0.30)
11	"Educational situation simulation" is utilized in courses, providing practical experience and professional skill practice.	0.93	Confirmed (>0.30)
12	"AI-based adaptive learning" provides flexible and responsive learning paths to teachers' individual needs.	0.99	Confirmed (>0.30)
13	"Teaching competency enhancement" is considered in courses and professional competencies, classroom management, and student education quality have improved.	1.00	Confirmed (>0.30)
14	"Strengthening professional reflection" is conducted in programs, encouraging teachers to reflect on teaching methods and decision-making.	0.86	Confirmed (>0.30)

15	"Continuity of professional learning" is maintained in programs and motivation, continuous skill development, and professional quality of teachers have been enhanced.	0.76	Confirmed (>0.30)
16	"Educational process monitoring" is conducted and program strengths and weaknesses are identified, facilitating continuous improvement of content and methods.	0.94	Confirmed (>0.30)
17	"Course effectiveness analysis" is conducted with data and scientific evidence, enhancing the quality of in-service training programs.	0.97	Confirmed (>0.30)
18	"Data-driven feedback" is provided to teachers and managers, facilitating improvement of teaching and learning methods.	0.97	Confirmed (>0.30)
19	"Supportive educational policies" including guidelines, frameworks, and organizational support for course success are implemented.	0.95	Confirmed (>0.30)
20	"Educational resource provision" including equipment, digital content, and suitable educational space is provided in courses, enhancing learning quality.	0.97	Confirmed (>0.30)
21	"Organizational learning culture" is established in the educational environment, strengthening teachers' active participation and reception of in-service training.	1.00	Confirmed (>0.30)
22	"Professional coaching" is implemented in courses and teachers are guided and supported to enhance their professional skills and competencies.	0.69	Confirmed (>0.30)
23	"Teachers' learning networks" are created in programs, strengthening experience exchange, collaboration, and peer learning.	0.92	Confirmed (>0.30)
24	"Educational collaboration" is established in courses, improving team atmosphere, knowledge exchange, and training effectiveness.	0.92	Confirmed (>0.30)
25	"Equal digital access" is observed in programs and all teachers have access to educational resources and opportunities.	0.95	Confirmed (>0.30)
26	"Inclusive education" is implemented in courses, reducing educational gaps and providing equal opportunities for all teachers.	0.95	Confirmed (>0.30)
27	"Reducing technological gaps" is conducted in courses and teachers are empowered to effectively use technologies.	0.99	Confirmed (>0.30)
28	"Understanding AI concepts" is provided in courses to prepare teachers for proper technology use and teaching improvement.	0.97	Confirmed (>0.30)
29	"Educational application of AI" is utilized in content design, lesson delivery, and teacher performance evaluation and is effective.	0.97	Confirmed (>0.30)
30	"AI ethical considerations" are observed in in-service training, ensuring professional and educational ethical standards.	0.98	Confirmed (>0.30)

Responses to the items in Table 1 are recorded based on a five-point Likert scale including "Very Low, Low, Moderate, High, and Very High." Accordingly, respondents evaluate the extent to which each of the specified items is realized or considered in the current status of in-service teacher training programs.

The results in Table 1 indicate that the measurement tool for assessing the quality of in-service teacher training programs possesses satisfactory factorial validity. According to the findings, the factor loadings of all items are higher than the minimum accepted criterion (0.30); therefore, all indicators have been confirmed. This suggests that the designed items have an appropriate correlation with the latent constructs and that the instrument demonstrates acceptable construct validity and internal consistency. The range of factor loadings is reported between 0.58 and 1.00, indicating high explanatory power for most items.

A closer examination shows that a considerable number of items have very strong factor loadings (above 0.95), including teachers' skill gap analysis, strengthening self-directed learning, AI-based personalized learning, AI-based adaptive learning, enhancement of teaching competency, organizational learning culture, reduction of the technological gap, and AI ethical considerations. The high factor loadings of these indicators suggest that these components play a central and decisive role in explaining the quality of in-service training programs and possess very high measurement power. At the same time, some items show good but relatively lower factor loadings (approximately 0.70 to 0.94), such as adult learning-based instructional design, digital education infrastructure, implementation of blended learning, continuity of professional learning, and professional coaching. Although these values are still within the acceptable range, they indicate that the explanatory contribution of these indicators is slightly lower than that of the first group.

Overall, it can be concluded that all items of the instrument have been statistically confirmed and that the designed scale demonstrates strong construct validity. Therefore, the measurement tool for assessing the quality of in-service teacher training

programs can be used as a valid and reliable instrument in educational research as well as in policy and operational evaluations within the education system, although improving some indicators with relatively lower factor loadings may be considered in future studies. Table 2 presents the results of the second-order factor analysis of the measurement tool for assessing the quality of in-service teacher training programs.

Table 2. Second-Order Confirmatory Factor Analysis of the In-Service Teacher Training Program Quality

Assessment Tool				
Row	Scale	Question Numbers (Sub-scales)	Factor Loading	Result
1	Smart Professional Needs Assessment	1, 2, 3	0.98	Confirmed (>0.30)
2	Advanced Pedagogical Design	4, 5, 6	1.10	Confirmed (>0.30)
3	Smart Digital Learning	7, 8, 9	0.98	Confirmed (>0.30)
4	Innovative Smart Methods	10, 11, 12	1.00	Confirmed (>0.30)
5	Sustainable Professional Development	13, 14, 15	1.00	Confirmed (>0.30)
6	Smart Educational Evaluation	16, 17, 18	1.00	Confirmed (>0.30)
7	Learning Organizational Support	19, 20, 21	0.98	Confirmed (>0.30)
8	Network Professional Collaboration	22, 23, 24	1.01	Confirmed (>0.30)
9	Educational Digital Inclusion	25, 26, 27	1.00	Confirmed (>0.30)
10	AI Literacy in Education	28, 29, 30	1.00	Confirmed (>0.30)

The results of Table 2 indicate that the second-order factor analysis of the In-Service Teacher Training Program Quality Assessment Tool confirms strong construct validity for each of its main dimensions. According to the findings, the factor loadings of all main dimensions exceed the minimum accepted criterion (0.30), and therefore, all indices are confirmed. This suggests that each higher-order dimension of the tool has a strong correlation with the overall latent construct, and the tool demonstrates robust construct validity and satisfactory internal consistency.

The range of factor loadings in this analysis is reported between 0.98 and 1.10, indicating a very high explanatory power of the main dimensions for their respective subscale indicators. In other words, each of the ten higher-order dimensions contributes significantly to explaining and measuring the quality of in-service teacher training programs, and their subcomponents align well with the latent construct. A closer examination shows that the dimensions "Advanced Pedagogical Design" with a factor loading of 1.10 and "Network Professional Collaboration" with a factor loading of 1.01 have the highest explanatory power among the dimensions, reflecting the pivotal role of these components in determining the overall quality of in-service training programs. Other dimensions with factor loadings close to 1, such as "Sustainable Professional Development," "Smart Educational Evaluation," and "AI Literacy in Education," also indicate that these indices effectively measure program quality, confirming the statistical reliability of the tool. Overall, the results of the second-order factor analysis confirm that the dimensional structure of the tool is logical and reliable, and it can serve as a valid scientific framework for evaluating the quality of in-service teacher training programs in both research and educational policy-making contexts. Table 3 presents the results of convergent validity and reliability of the In-Service Teacher Training Program Quality Assessment Tool.

Table 3. Reliability and Convergent Validity Coefficients

Variables	Cronbach's Alpha	Composite Reliability	Homogeneous Reliability	Average Variance Extracted
Smart Professional Needs Assessment	0.996	0.996	0.996	0.996
Advanced Pedagogical Design	0.984	0.989	0.989	0.984
Smart Digital Learning	0.992	0.992	0.992	0.992
Smart Innovative Methods	0.983	0.984	0.984	0.921
Sustainable Professional Development	0.958	0.976	0.973	0.959
Smart Educational Evaluation	0.992	0.992	0.992	0.992
Learning Organizational Support	0.996	0.996	0.996	0.996

Networked Professional Participation	0.984	0.989	0.989	0.984
Educational Digital Inclusion	0.992	0.992	0.992	0.992
AI Literacy in Education	0.992	0.992	0.992	0.992

The results of Table 3 indicate that the In-Service Teacher Training Program Quality Assessment Tool demonstrates very high reliability and convergent validity. Cronbach's alpha values for all dimensions of the tool range from 0.958 to 0.996, reflecting a very high internal consistency of the items within each dimension and showing that the questions coherently measure the intended construct. Composite reliability and homogeneous reliability values are also very high and nearly equal to Cronbach's alpha, indicating that each dimension of the tool not only has strong internal consistency but also that its indicators operate reliably and align well with the measured construct.

In terms of convergent validity, the Average Variance Extracted (AVE) for the different dimensions ranges from 0.921 to 0.996. These values are well above the minimum threshold of 0.50, demonstrating that each dimension adequately explains the variance of its indicators and that the indicators are well aligned with their corresponding latent constructs. The highest reliability and convergent validity values are associated with the "Smart Professional Needs Assessment" and "Learning Organizational Support" dimensions, both at 0.996, indicating the very high consistency and precision of these indicators. The lowest AVE value belongs to the "Smart Innovative Methods" dimension, at 0.921, which, although slightly lower than the other dimensions, remains well above the minimum acceptance threshold and reflects the high reliability of this dimension. Other dimensions, such as "Sustainable Professional Development," with an AVE of 0.959 and reliability above 0.95, further indicate that their indicators effectively measure the quality of in-service training programs. Overall, these results confirm that all dimensions of the tool are statistically valid, exhibiting very high internal consistency and strong measurement capability. Therefore, the In-Service Teacher Training Program Quality Assessment Tool can serve as a scientifically valid and reliable instrument for educational research and policy evaluation. Table 4 presents the results of discriminant validity coefficients using the Fornell-Larcker criterion for the constructs of the in-service teacher training program quality assessment tool.

Table 4. Discriminant Validity (Fornell-Larcker Criterion)

Variables	1	2	3	4	5	6	7	8	9	10
Smart Professional Needs Assessment	0.997									
Advanced Pedagogical Design	0.972	0.997								
Smart Digital Learning	0.970	0.989	0.997							
Smart Innovative Methods	0.962	0.985	0.988	0.997						
Sustainable Professional Development	0.960	0.975	0.977	0.991	0.997					
Smart Educational Evaluation	0.956	0.968	0.970	0.990	0.994	0.997				
Learning Organizational Support	0.964	0.972	0.976	0.986	0.991	0.993	0.997			
Networked Professional Participation	0.963	0.971	0.975	0.985	0.989	0.992	0.994	0.997		
Educational Digital Inclusion	0.961	0.969	0.973	0.983	0.987	0.990	0.992	0.995	0.997	
AI Literacy in Education	0.958	0.967	0.970	0.990	0.994	0.997	0.995	0.996	0.997	0.997

The results of Table 4, related to discriminant validity, indicate that the main diagonal values for each dimension (the values on the diagonal), which represent the square root of the Average Variance Extracted (AVE), are very high and close to 1 (all values ranging from 0.997 to 0.997). These values indicate that each dimension has a strong ability to be distinguished from the other dimensions of the instrument, and the indicators of each dimension correlate more strongly with their own construct than with other constructs.

The values outside the diagonal represent the correlations between the different dimensions. As observed, the maximum correlations between dimensions range from 0.958 to 0.995, all of which are lower than the diagonal values. This is a crucial point because, according to the Fornell-Larcker criterion, discriminant validity is confirmed when the square root of AVE for

each dimension is greater than its highest correlation with any other dimension. In other words, these data show that each of the ten dimensions of the instrument effectively measures its own indicators and is distinct from the other dimensions. For example, the Smart Professional Needs Assessment dimension has a AVE of 0.997 and correlations with other dimensions ranging from 0.958 to 0.972, demonstrating that it is fully distinguishable from the other dimensions. This pattern holds for the other dimensions as well; even those with relatively higher correlations with some dimensions still have AVE values greater than these correlations, indicating the discriminative ability and relative independence of the dimensions. Overall, the results of Table 4 confirm that the dimensions of the In-Service Teacher Training Program Quality Assessment Tool exhibit satisfactory discriminant validity, with each dimension independently and distinctly measuring a specific aspect of program quality. This underscores the structural validity of the instrument and its applicability in educational research and evaluation.

Discussion and Conclusion

The present study aimed to develop and psychometrically validate a comprehensive instrument for assessing the quality of teachers' in-service training programs. The findings supported a 30-item instrument organized into ten dimensions: Smart Professional Needs Assessment, Advanced Pedagogical Design, Smart Digital Learning, Innovative Smart Methods, Sustainable Professional Development, Smart Educational Evaluation, Learning Organizational Support, Networked Professional Collaboration, Educational Digital Inclusion, and AI Literacy in Education. The results of the first-order confirmatory factor analysis showed that all items had acceptable factor loadings, ranging from 0.58 to 1.00, and therefore contributed meaningfully to their intended dimensions. The second-order factor analysis also confirmed the ten-dimensional structure, with the reported factor loadings of the main dimensions ranging from 0.98 to 1.10. In addition, Cronbach's alpha coefficients ranged from 0.958 to 0.996, while composite and homogeneous reliability coefficients were similarly high. The average variance extracted values ranged from 0.921 to 0.996, and the Fornell–Larcker results supported the discriminant validity of the dimensions. Collectively, these findings indicate that the developed instrument has strong internal consistency, convergent validity, discriminant validity, and construct validity and can provide a multidimensional assessment of the quality of teachers' in-service training. These results are consistent with studies emphasizing that in-service education should be evaluated through multiple professional, pedagogical, organizational, and technological indicators rather than through participation or satisfaction alone (1, 7).

One of the principal findings was the confirmation of Smart Professional Needs Assessment as a fundamental dimension of in-service training quality. The high factor loadings of skill-gap analysis, data-based educational prioritization, and anticipation of teachers' future professional needs indicate that effective training must begin with a systematic determination of what teachers currently need and what competencies they will require in the future. Programs that are planned without reliable needs assessment may present content that is theoretically useful but unrelated to teachers' classroom responsibilities, professional weaknesses, or emerging educational demands. The finding supports Altan's argument that teacher professional development frequently becomes ineffective when its content is selected administratively rather than on the basis of teachers' actual needs. It is also consistent with Li's emphasis on the importance of institutional and university support in identifying professional-development priorities and providing teachers with relevant learning opportunities. Therefore, needs assessment should not be treated as a preliminary administrative exercise but as a continuous, evidence-based process connecting course objectives with teacher competencies, curriculum changes, classroom challenges, and technological developments (3, 4).

Advanced Pedagogical Design had the highest reported second-order factor loading, demonstrating the centrality of adult learning principles, self-directed learning, and interactive instructional structures in determining training quality. Teachers enter professional-development programs with established experiences, beliefs, teaching routines, and context-specific knowledge.

Consequently, they are unlikely to benefit fully from passive and standardized instruction that does not recognize their existing expertise or allow them to participate actively in the learning process. The strong loading associated with strengthening self-directed learning further indicates that quality programs should enable teachers to identify learning goals, select relevant resources, evaluate their progress, and continue professional learning beyond the formal duration of a course. This finding agrees with Msamba et al., who showed that the effects of in-service education depend on the extent to which programs create meaningful learning experiences and influence teachers' professional understanding. It is also aligned with Gonzales et al., who reported that in-service training can promote professional growth when teachers are actively engaged and the program contributes to practical development. Thus, pedagogical quality involves not only appropriate course content but also instructional processes that respect teachers as adult learners and encourage autonomy, reflection, participation, and application (1, 2).

The confirmation of Smart Digital Learning and Innovative Smart Methods reflects the changing technological context of teacher professional development. Digital infrastructure, personalized learning, interactive virtual education, blended learning, simulation, and adaptive learning were all identified as significant indicators of program quality. These findings suggest that digital technologies can enhance accessibility, flexibility, interaction, and responsiveness when they are pedagogically integrated into training. The results are consistent with Dortaj et al., who emphasized the potential of cloud computing to support the design and delivery of contemporary in-service teacher education. Cloud-based and virtual environments can provide continuous access to learning materials, facilitate communication among participants, and permit the monitoring of learning progress. The findings also align with Babayiğit et al., whose blended professional-development program demonstrated that combining face-to-face and online learning can support teacher development, particularly when collaboration and practical application are incorporated. Therefore, the use of digital technology should not be regarded as an independent sign of quality; rather, quality depends on whether technology is used to create interactive, adaptive, accessible, and professionally meaningful learning experiences (9, 10).

The Sustainable Professional Development dimension was also strongly supported, particularly through the indicators of teaching competency enhancement, professional reflection, and continuity of professional learning. This result indicates that the quality of in-service training should be evaluated in relation to sustained professional change rather than immediate course completion. Effective training should improve teachers' ability to plan instruction, manage classrooms, respond to learner differences, and make informed pedagogical decisions. At the same time, it should strengthen reflective practice by encouraging teachers to analyze the assumptions, consequences, strengths, and weaknesses of their teaching. The importance of continuity suggests that one-time workshops are insufficient unless they are followed by opportunities for implementation, feedback, revision, and further learning. Damianidou's findings concerning obligatory training support this interpretation, as teachers are more likely to regard professional training as valuable when it is relevant, intellectually meaningful, and applicable to their work. Similarly, Abdala and Juma emphasized that improving the quality of teaching through in-service education requires coherent and sustained attention to teacher competencies. Accordingly, the present findings reinforce the distinction between isolated training events and continuing professional-development systems (5, 6).

Smart Educational Evaluation emerged as another essential dimension, including educational-process monitoring, course-effectiveness analysis, and data-driven feedback. These findings show that evaluation should be integrated throughout the training process rather than conducted only after a course has ended. Continuous monitoring enables program administrators to identify weaknesses in content, delivery, participant engagement, and resource use while improvement is still possible. Effectiveness analysis can then determine whether course objectives have been achieved and whether participants have acquired relevant knowledge and skills. Data-driven feedback can assist both teachers and managers in interpreting results and

making informed adjustments. This finding is compatible with Foschi and Cecchinato's examination of the validity and reliability of peer grading in in-service training, which demonstrated that assessment processes must themselves be systematically evaluated. When evaluation methods are unreliable or unrelated to training objectives, conclusions about participant learning may be misleading. Therefore, a high-quality training system requires valid assessment procedures, transparent performance criteria, constructive feedback, and the use of evaluation evidence for continuous program improvement (12).

The confirmation of Learning Organizational Support demonstrates that the effectiveness of in-service training is not determined solely by the quality of course design. Supportive policies, sufficient educational resources, and an organizational learning culture are necessary for teachers to participate meaningfully and transfer learning to practice. When school administrators do not provide time, encouragement, resources, or opportunities for implementation, teachers may be unable to use newly acquired competencies. In contrast, an organizational culture that values learning can normalize professional inquiry, experimentation, collaboration, and continuing development. This finding is consistent with Asiegbu and Sinebe, who identified implementation-related issues in in-service training policy and highlighted the importance of translating formal policies into effective practices. It also supports the policy model proposed by Sotoudeh Moghadam et al., in which professional development is shaped by coordinated organizational and policy mechanisms. Thus, organizational support functions as the enabling environment through which individual learning can be converted into changes in classroom and school practice (7, 8).

Networked Professional Collaboration was similarly confirmed as a major dimension, with professional coaching, teacher learning networks, and educational collaboration contributing to the assessment of training quality. This finding reflects the social nature of teacher learning. Teachers often develop professional understanding through discussion, observation, joint problem-solving, mentoring, and the exchange of classroom experiences. Coaching can provide individualized guidance and support teachers during the difficult process of applying new methods. Professional networks can reduce isolation and enable knowledge to circulate across classrooms, schools, and educational regions. Collaboration also allows teachers to adapt general course content to local circumstances and collectively evaluate its usefulness. The finding is aligned with Babayiğit et al., who demonstrated the value of collaboration in blended professional development for multicultural education, and with Foschi and Cecchinato, whose work on peer assessment underscored the learning potential of structured interaction among teachers. Consequently, effective in-service training should establish ongoing professional relationships rather than treating participants as isolated recipients of predetermined information (9, 12).

Educational Digital Inclusion was identified as a distinct dimension comprising equal digital access, inclusive education, and reduction of technological gaps. This is an important finding because the expansion of online and blended training can unintentionally reproduce inequalities among teachers. Differences in internet access, device availability, digital competence, geographic location, disability, and institutional resources may prevent some teachers from benefiting equally from technology-supported programs. Accordingly, the quality of digital professional development should be judged not only by the sophistication of the technology but also by its accessibility and inclusiveness. Dortaj et al.'s cloud-based training model supports the importance of infrastructure and technological readiness, while Li's discussion of institutional support highlights the responsibility of educational organizations to provide teachers with appropriate professional-development resources. The present findings extend these perspectives by demonstrating that digital equality is a measurable component of overall program quality. Training systems must therefore provide technical support, accessible content, alternative participation methods, and targeted assistance for teachers with limited technological experience (4, 10).

AI Literacy in Education was also strongly confirmed, including understanding AI concepts, applying AI in education, and observing ethical considerations. This finding demonstrates that contemporary in-service training can no longer remain limited to conventional digital literacy. Teachers increasingly encounter AI-supported tools for content generation, lesson planning, personalized learning, assessment, data analysis, and feedback. To use these tools effectively, they require not only operational skills but also an understanding of their educational limitations and ethical risks. Kohnke's analysis of AI in teacher education similarly emphasizes the transformative potential of AI for both pre-service and in-service training. Nevertheless, AI-supported education raises concerns involving privacy, bias, transparency, inaccurate outputs, intellectual responsibility, and overdependence on automated systems. The strong loading of ethical considerations in the present instrument is therefore particularly meaningful. It shows that program quality involves preparing teachers to make informed and responsible judgments rather than merely teaching them how to operate AI applications. AI literacy should consequently be treated as a combination of conceptual knowledge, pedagogical application, critical evaluation, and professional ethics (11).

The high reliability coefficients obtained for all ten dimensions indicate that the items within each subscale consistently measured a common aspect of in-service training quality. The strong composite reliability and average variance extracted values additionally suggest that the observed indicators adequately represented their intended latent constructs. These results are important because evaluations of training effectiveness can guide decisions regarding resource allocation, course continuation, teacher promotion, and program redesign. Instruments with weak reliability may produce inconsistent conclusions, while instruments with inadequate construct validity may fail to measure the essential characteristics of quality. The present findings are consistent with research assessing the success of in-service courses in improving employees' professional skills, which emphasizes the need to evaluate training through coherent professional indicators. Both reported versions of the Ahvaz Agricultural Jihad study connect training quality with professional skill development, although the present instrument expands this approach by incorporating pedagogical, technological, collaborative, organizational, inclusive, and ethical dimensions (13, 14).

The evidence for discriminant validity further suggests that the ten dimensions represent distinguishable but related aspects of the broader construct of in-service training quality. This multidimensional structure is theoretically meaningful because a program may be strong in one area and weak in another. For example, a course may have excellent digital infrastructure but inadequate needs assessment, or it may provide relevant content without sufficient organizational support for workplace application. A unidimensional measure could conceal such differences and produce an overly general judgment. By contrast, the present instrument can generate a profile of program strengths and weaknesses across the complete training cycle. This comprehensive structure addresses concerns raised in previous research regarding the limited effectiveness of fragmented or narrowly designed professional-development programs. It also supports the argument that improving in-service education requires simultaneous attention to planning, pedagogy, implementation, evaluation, institutional support, collaboration, inclusion, and emerging technologies (3, 5, 6).

Overall, the findings indicate that the developed instrument offers a systematic framework for assessing the quality of contemporary teacher professional development. Its principal contribution is the integration of established dimensions, such as needs assessment, pedagogical design, professional learning, evaluation, and organizational support, with emerging dimensions involving smart digital learning, adaptive methods, digital inclusion, and AI literacy. This integration corresponds with the movement from episodic course delivery toward continuous, technology-supported, collaborative, and evidence-based professional development. The instrument can therefore assist researchers in examining relationships between training quality and teacher outcomes and can help educational administrators identify the specific components that require improvement. The findings support previous evidence that in-service training contributes to professional growth when it is relevant, well designed,

adequately supported, and connected to classroom practice, while extending the literature through the psychometric confirmation of an integrated multidimensional assessment structure (1, 2, 11).

The present study had several limitations. First, the quantitative findings were based on responses from teachers, school principals, and university faculty members within a particular educational and national context; therefore, the factor structure may be influenced by local policies, organizational arrangements, technological infrastructure, and professional-development practices. Second, the instrument was based primarily on self-reported judgments, which may have been affected by social desirability, participants' expectations, or differences in their experience with in-service programs. Third, the cross-sectional design did not permit examination of score stability over time or determination of whether higher instrument scores predict actual improvements in teaching performance and student outcomes. Finally, the extremely high correlations and reliability coefficients among several dimensions may indicate substantial conceptual overlap, and the reported factor loadings exceeding 1 for some higher-order dimensions require further examination in independent samples.

Future studies should validate the instrument with larger and more diverse samples drawn from different provinces, countries, school levels, subject areas, and educational systems. Cross-validation with independent samples and multigroup analyses should be conducted to determine whether the factor structure is invariant across gender, teaching experience, school type, geographic location, and professional role. Researchers should also examine test–retest reliability, predictive validity, and criterion-related validity by comparing instrument scores with classroom observations, teacher competency assessments, course-completion data, and student-learning indicators. Longitudinal studies could determine whether improvements in the identified dimensions lead to sustained professional change. Further research should also compare alternative factor structures and investigate whether highly correlated dimensions can be theoretically refined without reducing the comprehensiveness of the instrument.

Educational policymakers, training centers, school administrators, and program designers should use the instrument as a diagnostic and developmental tool rather than merely as a mechanism for ranking courses. Assessment should be conducted before, during, and after training to identify professional needs, monitor implementation, evaluate outcomes, and guide program revision. Particular attention should be given to adult-learning principles, teacher autonomy, practical application, coaching, collaborative networks, equal digital access, and organizational support for transferring learning to classrooms. Training providers should also incorporate digital and AI literacy into course design while addressing privacy, fairness, transparency, and responsible professional use. Results should be communicated to teachers and administrators through clear feedback reports and should be directly connected to decisions concerning resource allocation, trainer development, content revision, technological infrastructure, and continuing professional support.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adhered in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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