

Validation and Prioritization of Factors Affecting Artificial Intelligence Literacy Education

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ABSTRACT

Purpose: The present study aimed to examine and determine the effects of presenteeism on professional productivity among faculty members of universities in North Khorasan.

Methods and Materials: This study was conducted using an exploratory mixed-methods design integrating qualitative and quantitative approaches. In the qualitative phase, key dimensions of presenteeism were identified through a comprehensive review of the literature and semi-structured interviews with academic and executive experts who had at least ten years of professional experience and relevant scholarly publications. The extracted indicators were refined and screened using the fuzzy Delphi technique to achieve expert consensus. In the quantitative phase, the proposed model was validated using a survey method. The statistical population consisted of approximately 1,300 faculty members, from which a sample of 296 participants was selected based on the Morgan and Krejcie table (1972). Data were collected using a researcher-developed questionnaire derived from the qualitative findings. The validity and reliability of the instrument were confirmed through content validity, construct validity, and internal consistency measures. Data analysis was performed using SPSS version 26 for preliminary analysis and Smart PLS version 3 for structural equation modeling.

Findings: The results of structural equation modeling indicated that presenteeism has a significant and strong effect on professional productivity ($\beta = 0.679$, $t = 16.177$, $p < 0.05$). The model demonstrated acceptable goodness-of-fit indices ($\chi^2/df = 2.79$, CFI = 0.95, GFI = 0.96, AGFI = 0.95, NFI = 0.97, NNFI = 0.96, RMSEA = 0.075), confirming the adequacy of the proposed structural model. These findings suggest that presenteeism is a key determinant of variations in professional productivity among faculty members.

Conclusion: The study concludes that presenteeism significantly influences professional productivity among faculty members and represents a critical factor affecting academic performance and organizational effectiveness. Addressing the underlying causes of presenteeism can enhance both employee well-being and institutional productivity.

Keywords: validation, prioritization, curriculum, artificial intelligence literacy education

1. Introduction

Artificial intelligence literacy has become one of the core educational requirements of contemporary societies because the rapid expansion of intelligent systems has transformed how learners access information, solve problems, communicate, create content, and participate in social and professional life. In educational systems, artificial intelligence is no longer limited to specialized computer science courses; rather, it increasingly affects curriculum design, teaching strategies, assessment methods, educational management, teacher empowerment, and learners' digital citizenship. This transformation has made artificial intelligence literacy a multidimensional construct that includes cognitive understanding, operational skills, ethical awareness, critical evaluation, and the capacity to interact effectively with generative and adaptive systems. Recent studies emphasize that education systems must move beyond instrumental use of artificial intelligence tools and develop systematic frameworks for preparing teachers and students to understand the theoretical foundations, applications, limitations, and social consequences of artificial intelligence (Padua, 2025; Rahimi, 2025; Zhou et al., 2025).

The significance of artificial intelligence literacy is particularly evident in curriculum development. A curriculum based on artificial intelligence literacy should not be reduced to technical training; rather, it must be designed as a comprehensive educational structure that integrates knowledge, skills, attitudes, values, assessment mechanisms, and implementation requirements. In this regard, digital culture in teaching is considered a prerequisite for quality education because teachers and learners need shared conceptual, ethical, and practical foundations for engaging with intelligent technologies (Padua, 2025). Similarly, systematic reviews of artificial intelligence literacy in K–12 education indicate that the construct includes definitional clarity, competency development, instructional strategies, and assessment approaches, all of which should be aligned within curriculum planning (Zhou et al., 2025). Therefore, validating and prioritizing the factors affecting artificial intelligence literacy education is essential for transforming scattered technological initiatives into a coherent curriculum model.

The cognitive dimension of artificial intelligence literacy is the foundation of any meaningful educational intervention in this field. Learners and teachers must understand what artificial intelligence is, how intelligent systems operate, what kinds of data-driven mechanisms support algorithmic

decision-making, and what limitations and errors may emerge from automated systems. Without such cognitive competencies, the use of artificial intelligence in education may remain superficial, dependent, and uncritical. Studies on artificial intelligence and education highlight the need for conceptual understanding of AI-driven systems, especially as these systems increasingly influence learning environments, professional communication, and educational decision-making (Sofologi et al., 2025; Tabishat & Hafiz, 2025). Moreover, emerging research on AI-supported education for students with attention-deficit/hyperactivity disorder shows that the cognitive, emotional, and ethical dimensions of AI must be considered together, since intelligent systems can support learning only when their mechanisms and implications are properly understood (Deep et al., 2026).

Skill competencies represent another essential dimension of artificial intelligence literacy education. These competencies include the ability to use artificial intelligence tools, analyze AI-generated outputs, interact effectively with generative systems, and employ intelligent technologies for problem-solving and knowledge production. In educational settings, the mere availability of AI tools does not guarantee effective learning; rather, teachers and students need operational skills that enable purposeful, reflective, and context-sensitive use. Research on vocational teachers has shown that artificial intelligence competencies are increasingly necessary for designing learning activities and adapting instruction to changing technological conditions (Rattanakha et al., 2025). Similarly, studies on higher education teachers indicate that artificial intelligence can support teaching, but this support depends on teachers' ability to integrate AI tools into pedagogical processes rather than using them as isolated technological aids (Tahir et al., 2025). Therefore, skill-based preparation must be treated as a central component of any curriculum model for artificial intelligence literacy.

Alongside cognitive and skill-based dimensions, attitudinal and ethical competencies are indispensable. Artificial intelligence systems raise important concerns related to intellectual property, academic integrity, algorithmic bias, digital responsibility, privacy, fairness, and learner autonomy. If educational systems focus only on technical skills without ethical and critical orientation, artificial intelligence literacy may unintentionally reproduce dependency, misinformation, bias, or irresponsible use. Research on artificial intelligence in academic environments has shown that AI may both reduce and increase learners'

anxieties depending on the way it is implemented and interpreted (Pertiwi et al., 2025). In health sciences education, students' attitudes and expectations toward AI are also shaped by professional communication needs and ethical considerations (Tabishat & Hafiz, 2025). These findings demonstrate that AI literacy education should cultivate responsible, critical, and self-regulated users rather than merely efficient users of digital tools.

Teacher empowerment is another major requirement for successful artificial intelligence literacy education. Teachers are not only users of artificial intelligence systems but also curriculum mediators, ethical guides, designers of learning experiences, and evaluators of student competencies. Accordingly, teacher training programs must be updated to include artificial intelligence and media literacy, particularly because teachers need to help students distinguish between credible information, algorithmically generated content, biased outputs, and educationally meaningful uses of AI (Скрипка, 2025). Research on the professional empowerment of teachers similarly emphasizes that artificial intelligence can contribute to educational development only when teachers are prepared to use it critically and pedagogically (Parseh et al., 2025). In physics classrooms, teachers' self-efficacy has been identified as an important factor in AI integration, indicating that confidence, competence, and pedagogical readiness are key determinants of implementation success (Yehya et al., 2025).

Artificial intelligence literacy also has important implications for educational leadership and management. As schools and higher education institutions adopt intelligent technologies, managers and policymakers must make decisions about infrastructure, teacher training, resource production, ethical governance, and assessment standards. Studies on educational leadership have proposed taxonomies for understanding the role of artificial intelligence in leadership, planning, and institutional transformation (Sposato, 2025). In the same vein, models for empowering managers of entrepreneurial schools through artificial intelligence indicate that managerial readiness and institutional support are necessary for translating AI potential into educational innovation (Sadeghi & Shafie Pour Motlagh, 2025). Thus, any validated model of artificial intelligence literacy education should include not only learner-level and teacher-level competencies but also organizational and policy-related requirements.

The role of artificial intelligence in reshaping educational content is also significant. In higher education, AI-driven

curriculum design has been discussed in relation to aesthetic education, animation training, ideological and political education, entrepreneurship education, and professional development. For example, AI-driven aesthetic education curricula demonstrate how intelligent technologies can support creativity, personalization, and new forms of content organization (Zheng, 2025). In animation education, artificial intelligence has influenced professional training modes by changing the skills required for creative production and digital design (B. Wang, 2025). In entrepreneurship education, bibliometric evidence suggests that AI is transforming both research agendas and educational practices, particularly by enabling new approaches to innovation, opportunity recognition, and entrepreneurial learning (Elsa et al., 2026). These developments show that AI literacy is not a narrow technological subject but a cross-curricular competency relevant to diverse fields.

Artificial intelligence also contributes to the development of soft skills and future-oriented competencies. Although AI is often associated with automation and technical efficiency, recent studies emphasize its role in communication, collaboration, creativity, critical thinking, and problem-solving. Teaching soft skills through artificial intelligence has been proposed as a promising approach for preparing students for complex social and professional environments (Zogopoulos et al., 2025). Similarly, research on future educators suggests that AI can contribute to the development of soft skills required for teaching in technologically enriched learning environments (Raissouni et al., 2025). These perspectives are closely related to AI literacy because learners must not only operate intelligent systems but also use them to support reflective judgment, collaborative learning, adaptive communication, and lifelong learning.

At the same time, artificial intelligence literacy education must recognize the cultural and value-based dimensions of technology integration. Educational systems are not value-neutral spaces, and the integration of AI inevitably intersects with cultural identity, ethical norms, ideological frameworks, and social expectations. Studies on AI-enabled ideological and political education show that artificial intelligence can influence communication modes, precision education, and value-oriented learning in higher education (Q. Wang, 2025; Yin et al., 2025). In related cultural fields, discussions of fashion design, modesty, and value-based educational contexts suggest that technology integration may also interact with local cultural norms and social meanings (Rah Shabdeez & Hasan Zadeh, 2025). Therefore,



curriculum models for AI literacy should be sufficiently flexible to allow localization, alignment with educational documents, and sensitivity to cultural contexts.

The use of artificial intelligence in secondary and high school education further highlights the necessity of age-appropriate and developmentally suitable curriculum planning. Reviews of AI use in high school education show that AI tools are increasingly being applied in teaching, learning, assessment, and student support, but their effectiveness depends on structured implementation and educational guidance (Perse, 2025). In K–12 contexts, defining and assessing AI literacy requires attention to students' developmental levels, teachers' preparedness, school infrastructure, and assessment validity (Zhou et al., 2025). These findings indicate that artificial intelligence literacy should be introduced through carefully designed curricular components rather than fragmented or incidental exposure to digital tools.

From a management and human resource perspective, AI literacy also has strategic significance for preparing educational institutions for broader social and economic transitions. Artificial intelligence is increasingly linked to workforce development, organizational innovation, and sustainable transformation. Research on the synergy between artificial intelligence and human resource management for circular economy transition illustrates how AI competencies can support organizational adaptation, sustainability, and strategic change (Rani, 2025). Although this perspective originates from management and organizational studies, it is relevant to education because schools and universities are responsible for preparing individuals who can function effectively in AI-mediated work environments. Thus, AI literacy education can be viewed as a strategic investment in human capital, employability, and institutional resilience.

Despite the growing body of literature on artificial intelligence in education, there remains a need for empirically validated models that identify, classify, and prioritize the key factors affecting AI literacy education. Many studies have discussed AI integration, teacher empowerment, digital culture, soft skills, curriculum innovation, leadership, and ethical issues separately, but fewer studies have combined these elements into a validated hierarchical framework. This gap is important because educational policymakers and curriculum designers require evidence-based priorities to allocate resources, design teacher training, develop assessment tools, and implement AI literacy programs effectively. Without validated

prioritization, curriculum development may become inconsistent, overly technology-centered, or disconnected from the actual competencies required by teachers and learners.

Accordingly, the present study addresses this need by validating and prioritizing the factors affecting artificial intelligence literacy education within a curriculum-oriented framework. By combining expert judgment, hierarchical prioritization, and confirmatory factor analysis, the study provides a structured basis for identifying which cognitive, skill-based, ethical, curricular, pedagogical, and implementation-related factors should receive greater emphasis in curriculum design. Such a model can support educational managers, curriculum planners, teacher educators, and policymakers in designing coherent programs that move beyond basic digital tool use and toward comprehensive AI literacy. The aim of the present study was to validate and prioritize the factors affecting artificial intelligence literacy education in order to provide an empirically grounded framework for designing a desirable curriculum based on AI literacy.

2. Methods and Materials

This study was applied in terms of purpose and quantitative in nature. The statistical population consisted of all teachers with 10 years of professional experience holding master's and doctoral degrees in educational psychology and curriculum planning, artificial intelligence professors, specialists in education and curriculum planning, textbook authors, and experienced secondary school teachers in West Azerbaijan Province. A total of 50 participants were selected as the research sample through cluster sampling. A researcher-developed questionnaire was used for data collection. The validity of the questionnaire was approved by the supervising professors based on four criteria: credibility, transferability, dependability, and confirmability. Confirmatory factor analysis and structural equation modeling were employed for data analysis. All calculations were performed using SmartPLS software.

3. Findings and Results

In the quantitative findings section, the prioritization of dimensions and components was conducted using the fuzzy analytic hierarchy process (FAHP), and the validation and testing of relationships among the dimensions of the conceptual model were examined using the partial least squares (PLS) method. In this section, the analytic hierarchy



process (AHP) was used to determine the relative importance and prioritization of the indicators. Accordingly, the hierarchical structure of the study is first explained, followed by the presentation and interpretation of the results

obtained from pairwise comparisons and the final weights of the indicators, in order to provide a scientific basis for designing the final model of AI-based virtual education within the educational system.

Table 1

Factors and Sub-Criteria Affecting the Desirable Curriculum Based on Artificial Intelligence Literacy Education

| Dimension | Symbol | Component | Symbol |
|---|--------|---|--------|
| Cognitive Competencies | C1 | Theoretical Foundations of Artificial Intelligence | C11 |
| | | Understanding the Operational Mechanisms of Intelligent Systems | C12 |
| | | Understanding Limitations and Errors | C13 |
| Skill Competencies | C2 | Familiarity with Transformational Applications of Artificial Intelligence | C14 |
| | | Skills in Using Artificial Intelligence Tools | C21 |
| | | Skills in Analyzing and Evaluating Artificial Intelligence Outputs | C22 |
| | | Effective Interaction Skills with Generative Systems | C23 |
| Attitudinal and Ethical Competencies | C3 | Problem-Solving and Knowledge Production with the Assistance of Artificial Intelligence | C24 |
| | | Digital Responsibility | C31 |
| | | Ethics and Intellectual Property | C32 |
| | | Justice and Algorithmic Bias | C33 |
| Curriculum Components | C4 | Critical Thinking and Self-Regulation | C34 |
| | | Future Orientation and Lifelong Learning | C35 |
| | | Competency-Based Objectives | C41 |
| | | Content Organization and Integration | C42 |
| | | Localization and Alignment with Educational Documents | C43 |
| Teaching–Learning and Assessment Strategies | C5 | Emphasis on Application and Problem Orientation | C44 |
| | | Active and Project-Based Learning | C51 |
| | | Performance-Based and Process-Oriented Assessment | C52 |
| Requirements and Implementation Contexts | C6 | Assessment of Artificial Intelligence Skills and Attitudes | C53 |
| | | Teacher Empowerment | C61 |
| | | Technological Infrastructure | C62 |
| | | Policy and Managerial Support | C63 |
| | | Resource and Guideline Development | C64 |

After collecting expert opinions, the geometric mean technique was used to aggregate the responses. To perform

the hierarchical analysis, the main components were first compared pairwise based on the research objective.

Table 2

Pairwise Comparison Matrix of the Main Factors

| Criteria | C1 | C2 | C3 | C4 | C5 | C6 |
|----------|-------|-------|-------|-------|-------|-------|
| C1 | 1.872 | 1.000 | 0.583 | 1.872 | 1.000 | 1.913 |
| C2 | 1.545 | 1.717 | 1.000 | 0.646 | 0.523 | 1.000 |
| C3 | 1.000 | 0.756 | 1.125 | 1.000 | 5.196 | 1.754 |
| C4 | 1.756 | 1.000 | 0.583 | 1.872 | 0.280 | 0.869 |
| C5 | 0.560 | 0.545 | 1.000 | 0.540 | 1.000 | 1.913 |
| C6 | 0.575 | 0.565 | 1.000 | 0.540 | 0.523 | 1.000 |

The next step involved calculating the geometric mean of each row in order to determine the weights of the criteria.

Table 3

Eigenvector of the Indicators

| Criteria | Symbol | Geometric Mean | Eigenvector | Rank |
|---|--------|----------------|-------------|------|
| Cognitive Competencies | C1 | 1.056 | 0.150 | 1 |
| Skill Competencies | C2 | 1.028 | 0.146 | 2 |
| Attitudinal and Ethical Competencies | C3 | 1.013 | 0.144 | 3 |
| Curriculum Components | C4 | 0.990 | 0.141 | 4 |
| Teaching–Learning and Assessment Strategies | C5 | 0.970 | 0.139 | 5 |
| Requirements and Implementation Contexts | C6 | 0.920 | 0.137 | 6 |

Based on the obtained eigenvector, the factor of cognitive competencies, with a normalized weight of 0.150, had the highest priority. The remaining indicators were prioritized as follows: skill competencies with a normalized weight of 0.146 ranked second, attitudinal and ethical competencies with a normalized weight of 0.144 ranked third, curriculum

components with a normalized weight of 0.141 ranked fourth, teaching–learning and assessment strategy factors with a normalized weight of 0.139 ranked fifth, and requirements and implementation context components with a normalized weight of 0.137 ranked sixth.

Table 4

Final Prioritization of Sub-Criteria Using the AHP Technique

| Criterion | Sub-Criterion | Weight | Final Weight | Rank |
|---|---|--------|--------------|------|
| Cognitive Competencies (0.150) | Theoretical Foundations of Artificial Intelligence | 2.439 | 0.318 | 1 |
| | Understanding the Operational Mechanisms of Intelligent Systems | 2.093 | 0.273 | 2 |
| | Understanding Limitations and Errors | 0.679 | 0.089 | 11 |
| | Familiarity with Transformational Applications of Artificial Intelligence | 0.273 | 0.036 | 14 |
| Skill Competencies (0.146) | Skills in Using Artificial Intelligence Tools | 2.026 | 0.033 | 15 |
| | Skills in Analyzing and Evaluating Artificial Intelligence Outputs | 1.348 | 0.175 | 4 |
| | Effective Interaction Skills with Generative Systems | 1.611 | 0.209 | 3 |
| | Problem-Solving and Knowledge Production with the Assistance of Artificial Intelligence | 0.628 | 0.082 | 12 |
| Attitudinal and Ethical Competencies (0.144) | Digital Responsibility | 0.345 | 0.058 | 13 |
| | Ethics and Intellectual Property | 1.348 | 0.175 | 5 |
| | Justice and Algorithmic Bias | 1.611 | 0.109 | 8 |
| | Critical Thinking and Self-Regulation | 1.439 | 0.140 | 6 |
| | Future Orientation and Lifelong Learning | 1.468 | 0.111 | 7 |
| Curriculum Components (0.141) | Competency-Based Objectives | 0.720 | 0.094 | 9 |
| | Content Organization and Integration | 0.679 | 0.089 | 10 |
| | Localization and Alignment with Educational Documents | 2.023 | 0.023 | 16 |
| | Emphasis on Application and Problem Orientation | 2.026 | 0.0198 | 19 |
| Teaching–Learning and Assessment Strategies (0.139) | Active and Project-Based Learning | 2.030 | 0.0190 | 22 |
| | Performance-Based and Process-Oriented Assessment | 2.024 | 0.021 | 17 |
| Requirements and Implementation Contexts (0.137) | Assessment of Artificial Intelligence Skills and Attitudes | 20.027 | 0.0195 | 20 |
| | Teacher Empowerment | 2.032 | 0.0180 | 23 |
| | Technological Infrastructure | 2.031 | 0.0179 | 24 |
| | Policy and Managerial Support | 2.025 | 0.020 | 18 |
| | Resource and Guideline Development | 2.028 | 0.0192 | 21 |

Based on the results presented in Table 4, the final prioritization indicated that the sub-criterion “Theoretical Foundations of Artificial Intelligence,” with a final weight of 0.318, ranked first. “Understanding the Operational

Mechanisms of Intelligent Systems,” with a weight of 0.273, ranked second. “Effective Interaction Skills with Generative Systems,” with a final weight of 0.209, ranked third. The

remaining sub-criteria were ranked from 4 to 24, as presented in the above table.

After identifying the components and prioritizing the dimensions of AI-based virtual education using the Analytic Hierarchy Process (AHP), confirmatory factor analysis

(CFA) was employed in the next stage as an inferential and model-based approach in order to evaluate the degree of fit between the empirical data and the theoretical structure derived from the Delphi and AHP stages.

Figure 1

Standardized Factor Loadings of the Virtual Education Model Using Artificial Intelligence

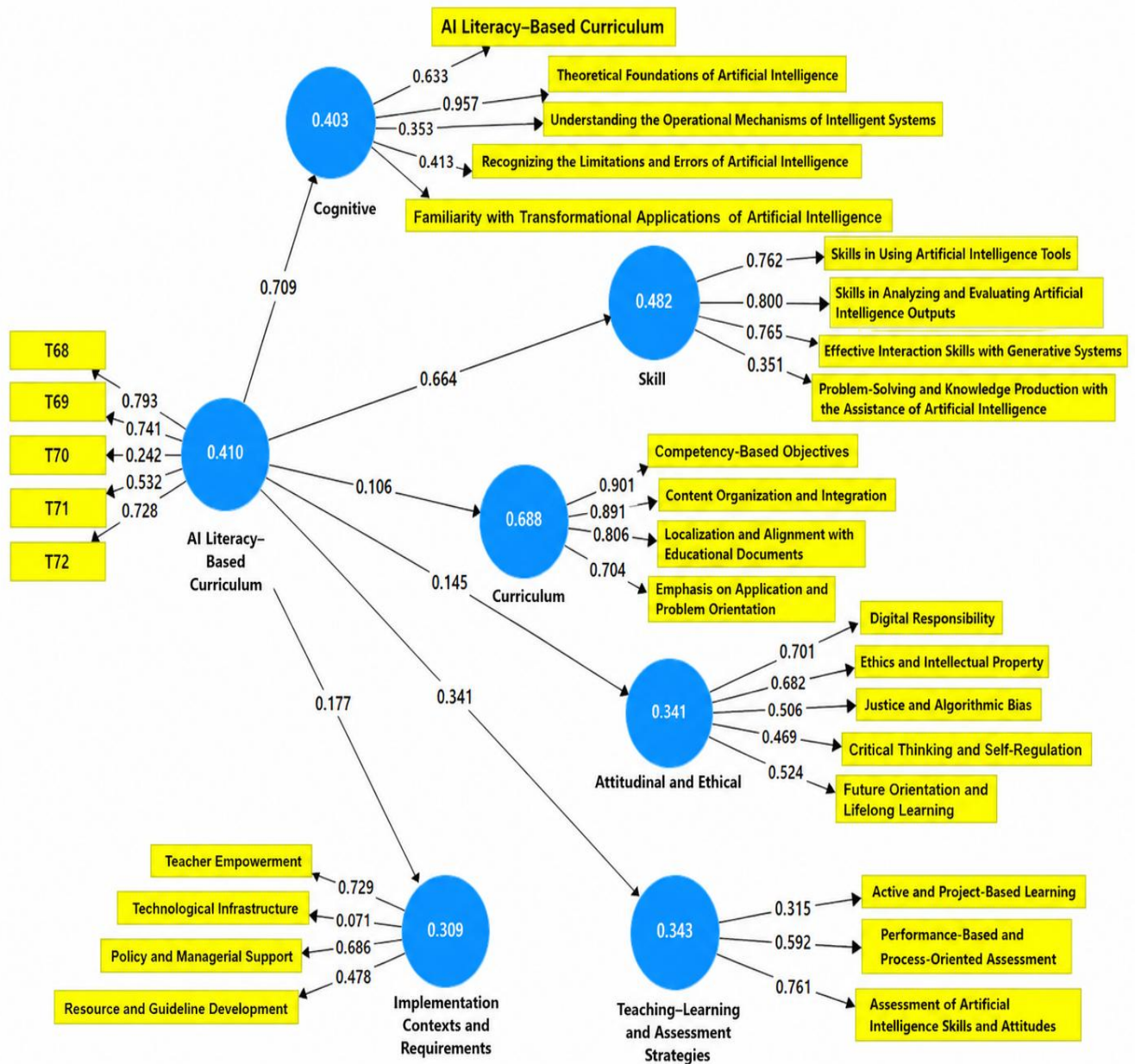
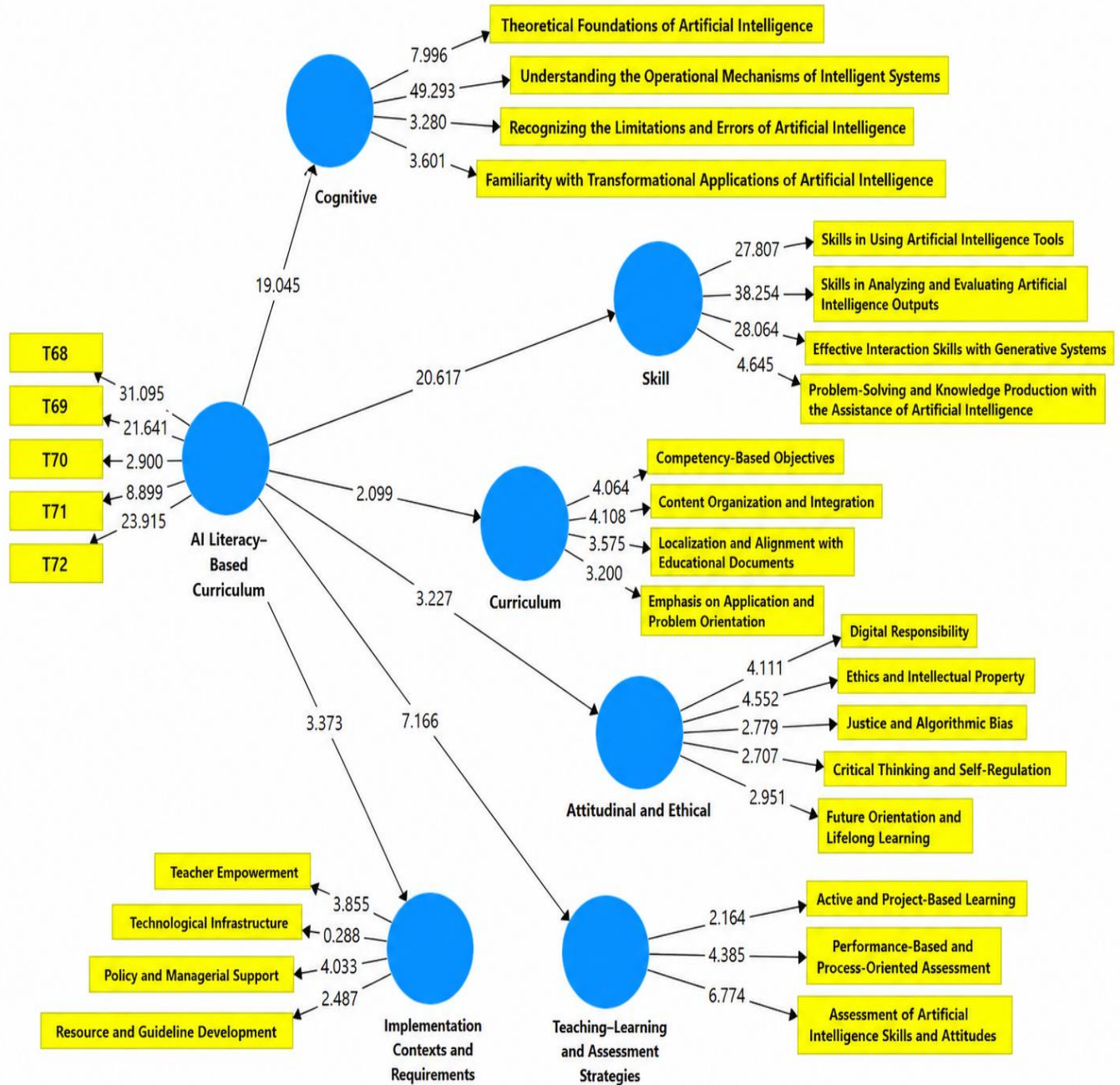


Figure 2

Standardized t-Values of the Virtual Education Model Using Artificial Intelligence



Examination of the t-statistics related to the paths between the items and the first-order constructs indicates that all items are statistically significant at the 95% confidence level. The t-statistic values for all paths are

significantly greater than the threshold value of 1.96, indicating confirmation of the measurement relationships and non-rejection of the null hypothesis across all indicators.

Table 5

Results of the First-Order and Second-Order Confirmatory Factor Analysis

| Items | First-Order Factor Loading | t-Statistic | p-Value | Second-Order Factor Loading | t-Statistic | p-Value |
|--|----------------------------|-------------|---------|-----------------------------|-------------|---------|
| Cognitive <- Q1 | 0.682 | 13.140 | 0.000 | 0.796 | 26.410 | 0.000 |
| Cognitive <- Q2 | 0.827 | 26.782 | 0.000 | | | |
| Cognitive <- Q3 | 0.863 | 35.942 | 0.000 | | | |
| Cognitive <- Q4 | | | | | | |
| Skill <- Q5 | 0.823 | 18.366 | 0.000 | 0.840 | 38.739 | 0.000 |
| Skill <- Q6 | 0.852 | 28.057 | 0.000 | | | |
| Skill <- Q7 | 0.873 | 31.440 | 0.000 | | | |
| Skill <- Q8 | 0.825 | 27.528 | 0.000 | | | |
| Attitudinal and Ethical <- Q9 | 0.888 | 49.261 | 0.000 | 0.827 | 24.505 | 0.000 |
| Attitudinal and Ethical <- Q10 | 0.871 | 34.806 | 0.000 | | | |
| Attitudinal and Ethical <- Q11 | 0.716 | 13.689 | 0.000 | | | |
| Attitudinal and Ethical <- Q12 | 0.722 | 14.514 | 0.000 | | | |
| Attitudinal and Ethical <- Q13 | 0.882 | 42.050 | 0.000 | | | |
| Curriculum Components <- Q14 | 0.797 | 16.884 | 0.000 | 0.836 | 25.183 | 0.000 |
| Curriculum Components <- Q15 | 0.863 | 34.733 | 0.000 | | | |
| Curriculum Components <- Q16 | 0.761 | 15.015 | 0.000 | | | |
| Curriculum Components <- Q17 | 0.882 | 42.050 | 0.000 | | | |
| Teaching–Learning and Assessment Strategies <- Q18 | 0.859 | 27.843 | 0.000 | 0.787 | 22.619 | 0.000 |
| Teaching–Learning and Assessment Strategies <- Q19 | 0.832 | 28.855 | 0.000 | | | |
| Teaching–Learning and Assessment Strategies <- Q20 | 0.799 | 28.929 | 0.000 | | | |
| Requirements and Implementation Contexts <- Q21 | 0.824 | 26.447 | 0.000 | 0.799 | 26.300 | 0.000 |
| Requirements and Implementation Contexts <- Q22 | 0.823 | 25.550 | 0.000 | | | |
| Requirements and Implementation Contexts <- Q23 | 0.764 | 12.238 | 0.000 | | | |
| Requirements and Implementation Contexts <- Q24 | 0.855 | 40.653 | 0.000 | | | |

The results of the first-order confirmatory factor analysis indicate that all items of the AI literacy–based curriculum model have acceptable factor loadings above the threshold value of 0.60. The t-statistic values for all items are significantly greater than 1.96, and their significance level was reported as 0.000. These findings indicate that the items significantly explain their corresponding latent constructs and possess desirable convergent validity. Specifically, in the cognitive dimension, the factor loadings ranged from 0.665 to 0.863, indicating appropriate conceptual coherence within this dimension. Furthermore, the skill, attitudinal and ethical, curriculum, teaching–learning and assessment strategies, and implementation requirements dimensions all demonstrated relatively high and significant factor loadings, indicating the adequacy of the indicators in measuring the various dimensions of the construct under study.

In the second-order confirmatory factor analysis, the six dimensions as first-order constructs were linked to the overarching construct of the AI literacy–based curriculum.

The results indicate that all second-order factor loadings are significant and at a desirable level. Their t-statistic values are all greater than 22, and their significance level is equal to 0.000. Among these dimensions, the skill dimension, with a factor loading of 0.840, and the curriculum dimension, with a factor loading of 0.836, had the greatest contribution to explaining the overarching construct, highlighting the central role of skill-based and curriculum infrastructures in the AI literacy–based curriculum. The remaining dimensions also contributed significantly to the formation of the overarching construct through acceptable factor loadings.

Overall, the results presented in Table 5 indicate that the measurement model of the study possesses strong construct and statistical validity at both the first-order and second-order levels. The significance of all factor loadings and the confirmation of the hierarchical structure of the model indicate that the conceptual framework of the study was properly designed and that the measurement instrument was

able to comprehensively and accurately cover the different dimensions of the AI literacy-based curriculum.

In the following section of the inferential findings, the reliability of the constructs is presented in Table 6.

Table 6

Cronbach's Alpha, rho_A Reliability, and Composite Reliability of the Research Constructs

| Variable | Cronbach's Alpha | rho_A Reliability | Composite Reliability |
|---|------------------|-------------------|-----------------------|
| Cognitive Competencies | 0.903 | 0.905 | 0.924 |
| Skill Competencies | 0.734 | 0.746 | 0.849 |
| Attitudinal and Ethical Competencies | 0.726 | 0.727 | 0.846 |
| Curriculum Components | 0.767 | 0.785 | 0.867 |
| Teaching-Learning and Assessment Strategies | 0.757 | 0.769 | 0.862 |
| Requirements and Implementation Contexts | 0.865 | 0.865 | 0.908 |

According to the results presented in Table 6, three indicators—Cronbach's alpha, rho_A reliability, and composite reliability (CR)—were used to evaluate the reliability of the measurement instrument for the research constructs. Simultaneous examination of these indicators provides a more accurate assessment of the internal consistency and reliability of the constructs. Based on accepted criteria in behavioral sciences and structural equation modeling studies, values above 0.70 indicate

acceptable reliability, whereas values above 0.80 indicate desirable reliability.

In the next section of the inferential findings, the validity of the research constructs is examined.

Convergent validity refers to the extent to which a latent variable is explained by its observable variables. For the Average Variance Extracted (AVE) index, a minimum acceptable value is 0.50. This value indicates that the observable variables explain at least 50% of the variance of their corresponding latent construct.

Table 7

Average Variance Extracted of the Research Constructs

| Variable | Average Variance Extracted (AVE) |
|---|----------------------------------|
| Cognitive Competencies | 0.638 |
| Skill Competencies | 0.653 |
| Attitudinal and Ethical Competencies | 0.647 |
| Curriculum Components | 0.686 |
| Teaching-Learning and Assessment Strategies | 0.677 |
| Requirements and Implementation Contexts | 0.712 |

To evaluate the convergent validity of the research constructs, the Average Variance Extracted (AVE) index was used. The AVE index indicates the extent to which each construct explains the variance of its indicators. Based on the criterion proposed by Fornell and Larcker, values greater than 0.50 indicate acceptable convergent validity. In other words, when the AVE value of a construct exceeds 0.50, it can be concluded that the construct explains more than half of the variance of its indicators.

The results presented in Table 7 indicate that all research constructs have AVE values higher than the threshold value of 0.50, demonstrating the complete establishment of convergent validity in the measurement model. The construct "Requirements and Implementation Contexts," with an AVE value of 0.712, exhibited the highest level of

explained variance. This finding indicates that the indicators of this construct strongly and coherently reflect the desirable curriculum based on AI literacy education.

The constructs "Curriculum Components" and "Cognitive Competencies," with AVE values of 0.686 and 0.638, respectively, also demonstrated high levels of convergent validity. These findings indicate that the items related to curriculum components and cognitive competencies were able to effectively explain their corresponding constructs. In addition, the construct "Teaching-Learning and Assessment Strategies," with an AVE value of 0.677, demonstrated appropriate explanatory power for the indicators associated with teaching-learning and assessment strategies.

Furthermore, the constructs “Skill Competencies” and “Attitudinal and Ethical Competencies,” with AVE values of 0.653 and 0.647, respectively, were both above the minimum acceptable threshold. These results indicate that, despite conceptual diversity, the indicators of these dimensions possess appropriate internal correlation and significantly measure their related latent constructs.

Overall, the results presented in Table 7 indicate that the measurement model of the study possesses strong and unambiguous convergent validity. The consistency of the AVE values with the factor loading results and reliability indices indicates that the research constructs were properly operationalized and that the measurement instrument was able to accurately and validly capture the theoretical concepts of the model. Accordingly, it can be concluded that the research model has been fully confirmed in terms of convergent validity, thereby providing the necessary conditions for evaluating discriminant validity and subsequently analyzing the structural model.

4. Discussion and Conclusion

The findings of the present study demonstrated that cognitive competencies achieved the highest priority among the dimensions affecting artificial intelligence literacy education, followed respectively by skill competencies, attitudinal and ethical competencies, curriculum components, teaching–learning and assessment strategies, and requirements and implementation contexts. Furthermore, the results of the final prioritization indicated that the sub-criteria of theoretical foundations of artificial intelligence, understanding the operational mechanisms of intelligent systems, and effective interaction skills with generative systems occupied the first to third ranks. The confirmatory factor analysis findings also showed that all dimensions and indicators possessed acceptable factor loadings, convergent validity, and composite reliability, confirming the structural validity of the proposed model for AI literacy–based curriculum design.

The prioritization of cognitive competencies as the most influential dimension indicates that artificial intelligence literacy education fundamentally depends on conceptual understanding rather than merely operational use of digital technologies. This finding suggests that learners and teachers must first understand the logic, principles, functions, and limitations of intelligent systems before they can effectively and ethically integrate them into educational contexts. The emphasis on theoretical foundations and

understanding intelligent system mechanisms aligns with systematic review findings indicating that AI literacy in educational environments requires definitional clarity, conceptual awareness, and cognitive preparedness regarding algorithmic systems (Zhou et al., 2025). Similarly, studies emphasizing digital culture in teaching have argued that quality education in the age of artificial intelligence depends on deep conceptual comprehension of technological transformations rather than superficial technological adaptation (Padua, 2025). Therefore, the present findings reinforce the argument that cognitive literacy represents the core infrastructure of educational readiness for artificial intelligence integration.

The prioritization of understanding the operational mechanisms of intelligent systems further reflects the growing need for transparency and interpretability in educational technology. Educational stakeholders increasingly interact with recommendation systems, generative AI tools, adaptive learning systems, and predictive analytics; however, without understanding how such systems process data and generate outputs, teachers and learners may become passive consumers of algorithmic decisions. This result is consistent with arguments presented in studies examining artificial intelligence in future education, where conceptual literacy and awareness of AI operations are viewed as prerequisites for responsible educational participation (Rahimi, 2025). Likewise, research on AI-driven educational communication models suggests that intelligent systems increasingly shape educational interactions and ideological communication, thereby requiring users to critically understand how such systems operate (Q. Wang, 2025; Yin et al., 2025).

The findings also revealed that skill competencies occupied the second highest priority, particularly the skill of effective interaction with generative systems. This result reflects the changing nature of educational participation in AI-mediated environments. In recent years, generative systems have become increasingly integrated into teaching, content production, assessment support, academic communication, and knowledge management. Consequently, learners and teachers require not only technical operational skills but also strategic interaction skills that enable them to formulate prompts, evaluate outputs, refine responses, and employ generative systems critically and creatively. This finding aligns with studies indicating that vocational teachers require AI competencies to design effective learning activities and technologically enriched educational experiences (Rattanakha et al., 2025).

Similarly, research on artificial intelligence support for higher education teachers demonstrated that meaningful AI integration depends on teachers' practical competence in adapting intelligent tools to pedagogical contexts (Tahir et al., 2025). Therefore, the present findings emphasize that operational interaction with AI systems is becoming a central educational competency.

Another important finding was the significant role of attitudinal and ethical competencies within the proposed model. Although this dimension ranked below cognitive and skill competencies, its factor loadings and reliability indicators demonstrated that it constitutes an essential component of AI literacy education. The increasing presence of artificial intelligence in educational systems raises critical ethical concerns related to algorithmic bias, academic integrity, digital responsibility, intellectual property, learner privacy, and misinformation. Consequently, educational systems cannot focus exclusively on technological efficiency without simultaneously cultivating ethical awareness and critical judgment. This finding is supported by research indicating that students' perceptions and expectations toward artificial intelligence are strongly influenced by ethical and professional considerations (Tabishat & Hafiz, 2025). Similarly, studies examining AI in academic environments found that intelligent technologies may both reduce and intensify learner anxiety depending on the context of use and students' attitudes toward AI-supported environments (Pertiwi et al., 2025). These results collectively suggest that emotional, ethical, and attitudinal readiness are indispensable for sustainable AI integration.

The relatively high ranking of curriculum components also indicates that artificial intelligence literacy cannot be effectively developed through isolated technological interventions or extracurricular activities. Instead, AI literacy requires systematic curricular integration involving competency-based objectives, content organization, localization, and problem-oriented learning approaches. This finding is consistent with research emphasizing the transformative influence of artificial intelligence on curriculum design in fields such as entrepreneurship education, aesthetic education, and professional training (Elsa et al., 2026; B. Wang, 2025; Zheng, 2025). These studies suggest that AI integration should not simply involve adding technological tools to existing curricula but should instead reshape educational goals, pedagogical structures, and competency frameworks. Therefore, the current findings support the necessity of curriculum redesign as a strategic

response to the expansion of artificial intelligence within educational systems.

The findings related to teaching–learning and assessment strategies further demonstrate that instructional methods and evaluation systems must evolve in response to artificial intelligence integration. Active and project-based learning, process-oriented assessment, and the evaluation of AI-related competencies emerged as important dimensions within the model. This finding reflects the broader pedagogical shift from memorization-based instruction toward competency-oriented and technology-supported learning environments. Previous research has shown that artificial intelligence can facilitate personalized, adaptive, and collaborative educational experiences when integrated through appropriate pedagogical strategies (Sofologi et al., 2025). Moreover, studies on AI-supported soft skills development have highlighted the role of artificial intelligence in enhancing communication, creativity, collaboration, and critical thinking within learning environments (Raissouni et al., 2025; Zogopoulos et al., 2025). Consequently, the present study confirms that teaching and assessment approaches must be redesigned to align with the multidimensional nature of AI literacy.

The dimension of requirements and implementation contexts, although ranked sixth, demonstrated acceptable factor loadings and explanatory power. This finding indicates that infrastructure, teacher empowerment, policy support, and educational resources remain essential prerequisites for implementing AI literacy curricula successfully. In many educational systems, technological innovation fails not because of conceptual weakness but because of inadequate infrastructure, insufficient teacher preparation, or lack of institutional support. The importance of teacher empowerment identified in the current study aligns with findings emphasizing that teachers require continuous professional development and self-efficacy support in order to integrate artificial intelligence effectively into classroom practices (Parseh et al., 2025; Yehya et al., 2025). Additionally, research on educational leadership and AI-based school management suggests that organizational readiness and strategic support significantly influence the success of technological transformation in educational institutions (Sadeghi & Shafie Pour Motlagh, 2025; Sposato, 2025). Therefore, although implementation contexts were ranked lower than cognitive and skill dimensions, they remain indispensable enabling conditions for AI literacy education.

The confirmatory factor analysis results provide further support for the validity of the proposed framework. All dimensions exhibited acceptable factor loadings, statistically significant t-values, strong convergent validity, and desirable reliability coefficients. These findings indicate that the identified dimensions collectively form a coherent and empirically supported structure for understanding AI literacy education. The strong second-order factor loadings of skill competencies and curriculum components suggest that these dimensions play particularly central roles in shaping the overarching construct of AI literacy-based curriculum design. This result is consistent with broader educational technology literature emphasizing that successful AI integration depends simultaneously on learner competencies and institutional curriculum transformation (Padua, 2025; Perse, 2025). Furthermore, the confirmation of the hierarchical structure demonstrates that AI literacy is not a fragmented collection of isolated competencies but rather a multidimensional and interconnected educational construct.

Another important implication of the findings concerns the relationship between artificial intelligence literacy and future workforce preparation. Contemporary societies increasingly require individuals who can interact critically and effectively with intelligent systems across professional, educational, and social contexts. Studies on AI and human resource management for circular economy transition have shown that AI competencies contribute to organizational adaptability, innovation, and sustainable development (Rani, 2025). Therefore, the present study suggests that AI literacy education should not be viewed solely as a technological educational initiative but also as a strategic investment in human capital development and social preparedness for digital transformation.

The findings additionally reflect the importance of contextual and cultural adaptation in AI literacy curriculum development. Educational systems operate within specific cultural, ethical, ideological, and institutional environments, and AI integration must therefore be localized and aligned with educational values and social expectations. Research on ideological and political education, as well as culturally grounded educational applications of artificial intelligence, demonstrates that AI systems interact with value systems, communication norms, and cultural identities (Rah Shabdeez & Hasan Zadeh, 2025; Q. Wang, 2025). Consequently, the emphasis on localization and alignment with educational documents in the present model appears particularly significant because it allows AI literacy

education to remain responsive to contextual educational priorities rather than relying on purely imported technological frameworks.

Overall, the present study contributes to the literature by developing and validating a multidimensional framework for AI literacy education that integrates cognitive, skill-based, ethical, curricular, pedagogical, and implementation-related dimensions. Unlike approaches that treat AI literacy primarily as a technical competency, the proposed model conceptualizes it as a comprehensive educational construct requiring balanced attention to conceptual understanding, practical competence, ethical responsibility, curriculum redesign, and institutional readiness. The findings therefore provide a scientific basis for policymakers, curriculum planners, educational leaders, and teacher educators seeking to design coherent and sustainable AI literacy programs within contemporary educational systems.

One limitation of the present study was the relatively limited sample size and its restriction to educational experts, teachers, and specialists from West Azerbaijan Province. Although the participants possessed relevant academic and professional expertise, the findings may not fully represent the perspectives of stakeholders from other educational regions or cultural contexts. In addition, the study relied on self-reported expert evaluations, which may be influenced by subjective judgment and contextual interpretation.

Future research should examine the proposed model across broader educational populations and different educational levels, including primary schools, higher education institutions, and technical-vocational systems. Comparative studies across different provinces and countries could provide deeper insights into the contextual adaptability of AI literacy curricula. Future studies may also investigate the practical implementation of the proposed framework through experimental curriculum interventions and longitudinal assessments of student and teacher competencies.

From a practical perspective, educational policymakers and curriculum planners should prioritize the integration of cognitive and skill-based AI literacy competencies into formal educational programs. Teacher training systems should be redesigned to strengthen educators' conceptual understanding of artificial intelligence, ethical awareness, and practical interaction skills with generative systems. Educational institutions should also invest in technological infrastructure, localized educational resources, and competency-based assessment systems to ensure effective and sustainable implementation of AI literacy education.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

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Declaration of Interest

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Ethical Considerations

All procedures performed in studies involving human participants were under the ethical standards of the institutional and, or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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