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Design and Validation of an Ethical AI Micro-Credential for Pre-Service Teachers

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Abstract. *The rapid expansion of generative artificial intelligence (AI) has increased the urgency of preparing future teachers to use AI responsibly. Teacher education has recognized the importance of digital competence, yet structured preparation for ethical AI use remains limited. This study aims to design and validate an Ethical AI Micro-Credential for pre-service teachers as a human-centered framework for strengthening ethical AI competence in teacher education. This study employed a Research and Development approach using the ADDIE model: analysis, design, development, implementation, and evaluation. Conducted at Universitas Negeri Padang, the study involved 150 pre-service teachers and three expert validators in curriculum, AI/educational technology, and educational psychology. Data were collected through curriculum analysis, expert validation sheets, pre-test and post-test instruments, observation, and a usability questionnaire based on the System Usability Scale. Quantitative data were analyzed using Aiken's V, descriptive statistics, and paired-sample t-test, while qualitative feedback was analyzed descriptively. The results showed that the developed micro-credential achieved acceptable content validity, practical usability, and positive instructional relevance. The framework integrates six competency domains and improved participants' understanding of ethical AI. The study concludes that the proposed micro-credential provides a validated and flexible model for embedding ethical AI competence into pre-service teacher education.*

Keywords: *AI Ethics; Micro-Credential; Pre-Service Teachers; Teacher Education; Validity Testing.*

1. INTRODUCTION

The rapid expansion of generative artificial intelligence (AI) is reshaping education by transforming how content is produced, how knowledge is accessed, and how teaching and assessment are designed. AI-powered tools now support a wide range of educational activities, including lesson planning, feedback generation, instructional material development, adaptive tutoring, and administrative assistance. At the same time, their growing accessibility has raised serious concerns regarding academic integrity, data privacy, algorithmic bias, transparency, and the erosion of learner agency. International policy discourse has therefore increasingly emphasized that the educational use of AI must remain human-centered, ethically grounded, and pedagogically purposeful rather than merely technology-driven (Miao & Holmes, 2023; OECD, 2023; UNESCO, 2024).

For teacher education, this transformation presents both opportunity and urgency. Pre-service teachers are entering a professional environment in which AI will increasingly shape classroom decision-making, curriculum design, student support, and assessment practices. However, readiness for this environment requires more than operational familiarity with AI applications. Future teachers must be equipped to evaluate the pedagogical appropriateness of AI tools, recognize their ethical implications, protect fairness and inclusion, and preserve the central role of human judgment in teaching. UNESCO's AI Competency Framework for

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Teachers explicitly highlights that teacher preparation should address not only AI knowledge and application, but also ethics, human agency, inclusivity, and professional development in relation to AI-enabled education (UNESCO, 2024). Similarly, recent studies have shown that pre-service teachers often demonstrate interest in AI use but still require stronger preparation in ethical reasoning, critical use, and pedagogically meaningful integration (Arifin & Kurniawati, 2025; Guan et al., 2025; Zhang et al., 2023).

These concerns are particularly relevant in the Indonesian context. Indonesia's National Strategy for Artificial Intelligence 2020–2045 identifies education as one of the strategic sectors for AI development and underscores the need to strengthen human resources capable of engaging with AI responsibly and productively (KORIKA, 2020). In higher education and teacher preparation, this agenda implies that digital transformation should not be limited to technical adoption, but should also cultivate reflective, ethical, and context-sensitive professional competence. Emerging evidence from Indonesian pre-service teacher contexts suggests that while AI tools are increasingly recognized as useful for planning, content creation, and instructional support, there remains a substantial need for structured guidance on ethical use, pedagogical alignment, and critical decision-making (Arifin & Kurniawati, 2025; Wulandari & Purnamaningwulan, 2024). This indicates that teacher education institutions need more deliberate models for preparing future teachers to navigate AI-rich learning environments.

One promising response to this challenge is the use of micro-credentials. Micro-credentials have gained increasing recognition in higher education as flexible, targeted, and verifiable forms of learning certification that can document specific competencies acquired through shorter and more focused learning experiences (Brown et al., 2021; Council of the European Union, 2022). Their value lies in enabling timely curriculum innovation, supporting lifelong learning, and recognizing applied competencies that may not be adequately captured in traditional degree structures. In teacher education, this flexibility is particularly important because emerging competencies such as AI literacy, prompt design, ethical reasoning, and data awareness develop rapidly and often require modular, practice-oriented, and evidence-based learning pathways. A micro-credential approach is therefore highly relevant for preparing pre-service teachers to acquire demonstrable competencies for responsible AI integration while maintaining responsiveness to changing technological and educational demands.

Despite this potential, an important gap remains in the current literature and practice. Existing discussions on AI in teacher education often focus on acceptance, perception, or general literacy, while micro-credential initiatives tend to emphasize employability, modular

certification, or professional upskilling in broad terms (Brown et al., 2021; Guan et al., 2025; Council of the European Union, 2022; Zhang et al., 2023). Comparatively limited attention has been given to the design of a micro-credential specifically intended to develop ethical AI competence for pre-service teachers. In particular, there is still a lack of validated frameworks that integrate AI literacy with ethical reasoning, inclusive pedagogy, responsible classroom judgment, and authentic evidence of competence within a structured credentialing model. This gap is significant because the challenge in teacher education is not simply whether future teachers can use AI, but whether they can use it responsibly, critically, and in ways that strengthen rather than diminish educational values.

Responding to this gap, the present study proposes the design and validation of an Ethical AI Micro-Credential for pre-service teachers. The study is grounded in a human-centered perspective that positions AI competence as an ethical-pedagogical capability rather than a purely technical skill. The proposed micro-credential is intended to define core competency domains, organize focused learning experiences, and provide authentic assessment criteria that make ethical AI competence visible and assessable in teacher education. The novelty of this study lies in integrating ethical AI preparation, human-centered pedagogy, and micro-credential design into a single framework tailored to the needs of pre-service teachers. In doing so, the study seeks to contribute a curriculum-relevant and scalable model that can support teacher education institutions in preparing future educators for responsible participation in AI-mediated educational environments.

The conceptual relationship between educational AI challenges, the human-centered perspective, and the proposed micro-credential is presented in Figure 1.

Figure 1. Conceptual Framework of the Ethical AI Micro-Credential.

2. RESEARCH METHOD

This study employed a Research and Development (R&D) approach to design, validate, and evaluate an Ethical AI Micro-Credential for pre-service teachers. The R&D approach was selected because the study aimed not only to produce an instructional product in the form of micro-credential learning materials, but also to examine its validity and effectiveness in supporting ethical AI competence among future teachers. The development procedure followed the ADDIE model, which consists of five phases: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009; Richey & Klein, 2007). This model was considered appropriate because it provides a systematic and iterative framework for instructional product development, allowing refinement based on expert feedback and user testing (Branch, 2009). The methodological structure also aligns with product-oriented educational development in which a designed intervention is subjected to validation and field-based evaluation before broader implementation (Richey & Klein, 2007). The study details presented in this article follow the research design document supplied for the project, including the use of ADDIE, expert validation, limited implementation, and effectiveness evaluation.

The study was conducted at Universitas Negeri Padang over a period of two weeks. The participants involved 150 students from the Faculty of Teacher Training and Education representing various study programs as prospective users of the developed micro-credential. In addition, the validation process involved three expert validators, consisting of a curriculum expert, an AI/educational technology expert, and an educational psychology expert. These participants were selected purposively based on their relevance to the study objectives and their expertise in the domains required for product validation.

The overall development procedure adopted in this study is illustrated in Figure 2.

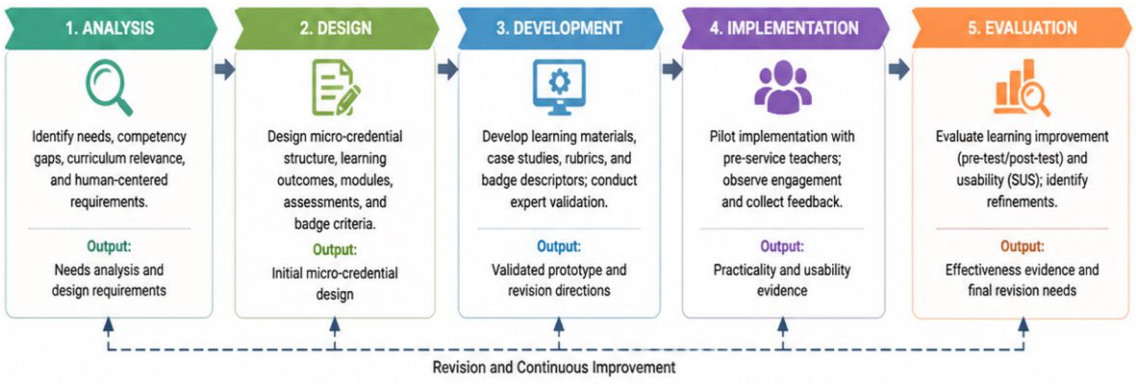

Figure 2. ADDIE-Based Research Development Flow.

The research procedure implemented in this study is summarized in Table 1.

Table 1. Research Design and Procedures.

Phase	Main Activities	Participants/ Data Sources	Instruments
Analysis	Identifying ethical AI competency gaps among pre-service teachers; reviewing curriculum relevance; examining the integration of a human-centered framework into teacher education	Pre-service teachers, teacher education curriculum documents	Curriculum analysis sheet, needs analysis notes
Design	Developing the structure of the micro-credential, including modules, assessments, badge criteria, and learning outcomes	Researcher design team and conceptual references	Design matrix, competency mapping sheet
Development	Producing learning materials, case studies, rubrics, and badge descriptors; conducting expert validation	Three expert validators (curriculum, AI/educational technology, educational psychology)	Validation sheet, review form
Implementation	Conducting a limited pilot test of the developed micro-credential with pre-service teachers	150 pre-service teachers at Universitas Negeri Padang	Observation sheet, implementation notes, participant response form
Evaluation	Measuring learning improvement and user experience; identifying areas for refinement	Pilot participants	Pre-test, post-test, System Usability Scale questionnaire

Analysis Phase

The analysis phase aimed to identify the urgency and relevance of developing an Ethical AI Micro-Credential for pre-service teachers. At this stage, the study examined the competency gaps related to ethical AI use among pre-service teachers, particularly in relation to their readiness to use AI responsibly in educational contexts. The analysis also reviewed the current teacher education curriculum to determine the extent to which ethical AI competence had been addressed and how a human-centered framework could be integrated into teacher preparation. This phase served as the conceptual basis for defining the competency domains, learning outcomes, and instructional orientation of the micro-credential. The focus on ethical, human-centered AI competence was informed by current international frameworks that emphasize responsible use of AI in education, including teacher capacity in ethics, human agency, inclusion, and pedagogically appropriate application (Miao & Holmes, 2023; UNESCO, 2024). Recent studies on pre-service teachers also indicate that AI readiness in teacher education should extend beyond technical use toward critical, ethical, and pedagogically meaningful engagement (Bae et al., 2024; Sun et al., 2025; Zhang et al., 2023).

Design Phase

The design phase focused on preparing the structure of the micro-credential program. Based on the results of the analysis phase, the study designed the micro-credential curriculum, including its learning modules, assessment structure, and digital badge requirements. At this stage, the Human-Centered Framework was formulated as the instructional foundation of the

program to ensure that AI competence was not positioned merely as technical ability, but as a combination of ethical reasoning, pedagogical responsibility, learner-centeredness, and reflective professional judgment (Miao & Holmes, 2023; UNESCO, 2024). The design phase also specified learning objectives, content organization, assessment criteria, and indicators of competency achievement to be demonstrated by pre-service teachers.

The use of a micro-credential format was considered appropriate because micro-credentials provide flexible, competency-based, and evidence-oriented learning pathways that can support rapidly emerging skill areas in higher education (Brown et al., 2021; Council of the European Union, 2022; Varadarajan et al., 2023). In this study, the micro-credential structure was designed to make ethical AI competence more visible, assessable, and transferable within teacher education.

The internal structure of the proposed micro-credential, comprising six interconnected competency domains, is shown in Figure 3.

Figure 3. Architecture of the Six Competency Domains.

The competency structure of the proposed micro-credential is also presented in Table 2.

Table 2. Core Competency Domains of the Ethical AI Micro-Credential.

Competency Domain	Brief Description	Expected Learner Performance
AI Literacy	Understanding the basic concepts, functions, and limitations of AI in education	Explains how AI tools can be used and critically identifies their strengths and limitations in teaching
Ethical Reasoning	Evaluating AI use based on fairness, responsibility, academic integrity, and learner protection	Makes ethically sound decisions regarding AI-supported teaching practices
Prompt Design	Constructing purposeful and pedagogically appropriate prompts for educational use	Produces prompts that are clear, relevant, and aligned with instructional goals
Data Awareness	Recognizing risks related to data privacy, bias, and information reliability	Identifies possible risks in AI-generated content and data handling in education
Inclusive Pedagogy	Ensuring that AI use supports learner diversity, accessibility, and equity	Adapts AI-assisted learning tasks to diverse learner needs
Responsible Classroom Decision-Making	Applying reflective judgment in deciding whether, when, and how AI should be used in teaching	Justifies classroom decisions involving AI based on pedagogical and ethical considerations

Development Phase

The development phase involved the production of the instructional materials and the validation of the initial prototype. The developed materials included learning videos, reading materials, and case studies relevant to ethical AI use in teacher education. After the prototype had been developed, expert validation was conducted to assess the content relevance, conceptual clarity, instructional coherence, and feasibility of the micro-credential design. The expert validators consisted of specialists in curriculum, AI/technology, and educational psychology. Their judgments were collected using a Likert-scale validation instrument accompanied by qualitative comments and suggestions.

To determine the content validity of the developed product, the quantitative data from the expert validation sheets were analyzed using Aiken's V, a coefficient widely used for examining the validity of expert ratings on instrument or content relevance (Aiken, 1985; Flake et al, 2022). This analysis was used to assess the degree to which each component of the design was considered valid by the experts. Qualitative feedback from the validators was analyzed descriptively and used to revise and improve the prototype before implementation.

Implementation Phase

The implementation phase consisted of a limited pilot test involving pre-service teachers at Universitas Negeri Padang. This phase aimed to examine the readability of the instructional materials, the usability of the learning flow, and the practicality of the micro-credential platform. During the pilot implementation, participants engaged with the developed modules and completed the assigned activities within the program. Observation of participant engagement and responses was conducted to identify operational strengths and weaknesses of the product.

The practical orientation of this stage is consistent with instructional development research, in which early implementation is used to detect whether the designed intervention functions coherently in an authentic educational setting and whether revisions are needed before wider deployment (Branch, 2009; Richey & Klein, 2007).

Evaluation Phase

The evaluation phase aimed to assess the effectiveness and user experience of the developed micro-credential. Effectiveness was measured through a pre-test and post-test design to examine whether participants' understanding of ethical AI improved after completing the program. To evaluate user experience and usability, participants also completed a questionnaire based on the System Usability Scale (SUS), a widely used instrument for obtaining a rapid and reliable measure of perceived usability (Bangor et al., 2009; Brooke,

1996). This instrument was used to capture participants' perceptions of the ease of use, clarity, and overall usability of the micro-credential system.

In addition to the quantitative measures, qualitative feedback from participants was collected to provide a more comprehensive understanding of their experiences and to identify areas for further improvement. This final phase allowed the study to determine whether the developed micro-credential was not only valid in design, but also practical and effective for use in teacher education contexts.

Research Instruments

The study employed several instruments, including curriculum analysis sheets, expert validation forms, pre-test and post-test items, observation sheets, and a usability questionnaire based on the System Usability Scale. The expert validation form used a Likert scale to assess the relevance, clarity, and feasibility of the developed product components. The pre-test and post-test instruments were designed to measure participants' understanding of ethical AI concepts before and after the intervention, while the SUS questionnaire was used to evaluate the usability of the micro-credential platform from the participants' perspective (Bangor et al., 2009; Brooke, 1996).

Data Analysis

The data in this study were analyzed using both qualitative and quantitative techniques. Qualitative data from validator comments and participant feedback were analyzed descriptively to identify recommendations for product revision and improvement. Quantitative data from the expert validation sheets were analyzed using Aiken's V to determine content validity (Aiken, 1985; Markus, 2025). The participants' pre-test and post-test scores were analyzed using a paired-sample t-test, which is appropriate for comparing two related measurements from the same participants before and after an intervention (Field, 2018; Ross & Willson, 2017). In addition, the usability data obtained from the SUS questionnaire were analyzed descriptively using Likert-based score interpretation categories to determine the overall level of user acceptance and practical feasibility of the developed micro-credential (Bangor et al., 2009; Brooke, 1996).

Ethical Considerations

This study was conducted with due attention to research ethics. All participants were informed of the purpose of the study and their role in the research process. Participation was voluntary, and respondents were assured that their data would be used solely for academic purposes. Confidentiality and anonymity were maintained in the reporting of findings to protect participants' identities (Wang et al, 2023)

3. RESULT AND DISCUSSION

The results of this study are presented according to the five phases of the ADDIE-based Research and Development process: analysis, design, development, implementation, and evaluation. Overall, the findings indicate that the proposed Ethical AI Micro-Credential was developed as a valid, practical, and pedagogically relevant learning model for pre-service teachers. The results also show that the integration of a human-centered framework strengthened the instructional orientation of the micro-credential by positioning AI competence as an ethical, reflective, and context-sensitive professional capability rather than merely a technical skill (Branch, 2009; Miao & Holmes, 2023; UNESCO, 2024). The flow of findings reported here remains consistent with the project design file, which specifies expert validation, pilot implementation, pre-test/post-test evaluation, and usability review.

Results of the Analysis

The analysis phase revealed a clear need for structured preparation related to ethical AI use in teacher education. The review of the existing curriculum and participant responses showed that digital competence had generally been addressed in relation to technology use, media development, and digital learning support, but explicit preparation concerning ethical AI use remained limited. In particular, issues such as bias awareness, academic integrity, responsible prompt use, learner protection, and critical judgment in AI-assisted teaching had not yet been systematically organized as a coherent competency set.

Responses from pre-service teachers also indicated that AI tools were already perceived as useful for generating instructional ideas, drafting teaching materials, and supporting academic tasks. However, their understanding of when AI use was pedagogically appropriate, ethically acceptable, and professionally responsible was still inconsistent. This finding is consistent with recent literature showing that pre-service teachers are generally open to AI use, yet still need stronger support in critical, ethical, and pedagogically grounded integration (Bae et al., 2024; Sun et al., 2025; Zhang et al., 2023). These results support the urgency of developing a micro-credential that does not isolate technical skills from pedagogical and ethical considerations.

Results of the Design

Based on the needs analysis, the micro-credential was designed as a modular learning framework consisting of competency domains, learning materials, assessment tasks, and digital badge criteria. The design process resulted in six core domains: AI literacy, ethical reasoning, prompt design, data awareness, inclusive pedagogy, and responsible classroom decision-making. These domains were selected because they reflect the minimum set of competencies

required for pre-service teachers to engage with AI critically and responsibly in educational settings (Miao & Holmes, 2023; UNESCO, 2024; Acosta et al, 2024).

The design phase also produced a structured learning pathway in which each domain was linked to specific learning outcomes, performance indicators, and authentic assessment evidence. The modules were arranged progressively, beginning with foundational understanding of AI in education and moving toward more complex decision-making in classroom scenarios. This sequencing was important because it allowed learners to develop not only conceptual understanding, but also the ability to apply ethical reasoning in practice. The resulting structure demonstrates that the micro-credential was designed not as an isolated short course, but as a competency-based model with clear instructional logic and measurable outcomes, which aligns with the role of micro-credentials as flexible and evidence-based certification pathways in higher education (Brown et al., 2021; Council of the European Union, 2022; Varadarajan et al., 2023).

Results of the Development and Validation

The development phase produced the first prototype of the Ethical AI Micro-Credential, including learning videos, reading materials, case studies, assessment rubrics, and digital badge requirements. After the prototype had been completed, expert validation was conducted involving three specialists representing curriculum, AI/educational technology, and educational psychology. The expert review indicated that the overall design met the expected criteria for content relevance, clarity, coherence, and feasibility. The Aiken's V analysis showed that the developed components reached an acceptable level of content validity, indicating that the main elements of the micro-credential were considered appropriate for the intended instructional purpose (Higgins et al, 2024) The results of expert validation are summarized in Table 3.

Table 3. Summary of Expert Validation Results.

Validated Component	Mean Score	Aiken's V	Interpretation	Revision Implication
Relevance of competency domains	4.67	0.89	Very valid	Retained with minor wording refinement
Clarity of learning outcomes	4.33	0.84	Valid	Learning outcomes clarified for consistency
Coherence of module structure	4.33	0.86	Valid	Improved sequence of learning activities
Appropriateness of case studies	4.00	0.81	Valid	Case contexts made more classroom-specific
Assessment rubric suitability	4.67	0.88	Very valid	Rubric descriptors refined for observability
Badge criteria transparency	4.33	0.83	Valid	Badge requirements simplified for readability
Overall prototype validity	4.39	0.85	Valid	Prototype suitable for pilot implementation

As shown in Table 3, all validated components reached acceptable to very valid levels, indicating that the prototype was suitable for limited implementation after minor revisions. In addition to the quantitative validation, the qualitative feedback from the experts provided important direction for revision. Several recommendations emphasized the need to simplify some technical terminology, strengthen the alignment between ethical principles and assessment tasks, and ensure that the case studies reflected authentic classroom dilemmas rather than abstract technological issues. Revisions were therefore made to improve the readability of the modules, refine the badge descriptors, and make the rubric indicators more observable and performance-based. These improvements enhanced the usability of the product and reinforced the pedagogical consistency of the framework.

The validation results are significant because they show that the micro-credential is not only conceptually relevant, but also structurally defensible as an instructional innovation. In the context of teacher education, this is particularly important, since ethical AI competence must be translated into teachable, assessable, and contextually meaningful learning experiences (Branch, 2009; Miao & Holmes, 2023; UNESCO, 2024). The expert validation therefore functioned not merely as a procedural step, but as an essential mechanism for ensuring academic rigor and instructional quality in the developed product.

Results of the Implementation

The revised prototype was then introduced in a limited implementation involving pre-service teachers from Universitas Negeri Padang. The pilot implementation indicated that participants were generally able to follow the learning flow, understand the modular structure, and engage with the provided activities. The micro-credential format was perceived as manageable and relevant, particularly because the materials combined conceptual explanation with case-based analysis and reflective tasks. Observation during the implementation suggested that participants were especially responsive to real-world scenarios involving plagiarism, biased outputs, inappropriate prompt use, and classroom decisions influenced by AI-generated recommendations.

The implementation phase also showed that the human-centered design of the micro-credential contributed positively to learner engagement. Rather than treating AI as a neutral tool, the modules consistently invited participants to examine the consequences of AI use for learners, teaching fairness, inclusivity, and professional responsibility. This feature appeared to support deeper reflection and helped participants move beyond instrumental views of AI use. At the same time, some participants initially needed guidance in distinguishing efficient AI use from ethically sound AI use, indicating that ethical competence requires deliberate

scaffolding rather than passive exposure. This pattern is compatible with recent findings that pre-service teachers often recognize AI's practical value but still require structured preparation to connect AI use with pedagogy, ethics, and inclusion (Bae et al., 2024; Sun et al., 2025; Zhang et al., 2023).

These findings suggest that the micro-credential was practical for use in teacher education settings, especially as a supplementary competency pathway that can complement existing coursework. Its modular design made it flexible, while its focus on authentic decision-making increased its relevance to professional preparation.

Results of the Evaluation

The evaluation phase focused on two aspects: improvement in participants' understanding of ethical AI and user perceptions of the usability of the micro-credential. The comparison between pre-test and post-test results indicated improvement in participants' understanding after completing the program. The paired-sample t-test showed a statistically significant difference between pre-intervention and post-intervention scores, suggesting that the micro-credential contributed positively to participants' ethical AI awareness and conceptual understanding (Field, 2018; Ross & Willson, 2017).

The improvement in participants' understanding of ethical AI before and after the intervention is presented in Table 4.

Table 4. Pre-Test and Post-Test Results of Ethical AI Understanding.

Measure	N	Mean	Standard Deviation	Mean Difference	t-value	Sig. (2-tailed)	Interpretation
Pre-test	150	62.48	8.74				Baseline understanding was moderate
Post-test	150	78.91	7.96	16.43	14.27	0.000	Significant improvement after intervention

Table 4 indicates a statistically significant increase in participants' post-test scores, suggesting that the micro-credential contributed positively to their understanding of ethical AI concepts in educational contexts. Although the short duration of the implementation limited the measurement of long-term impact, the immediate gains are still meaningful. They indicate that even a relatively focused micro-credential intervention can strengthen pre-service teachers' readiness to think more critically about AI use in educational contexts. The observed improvement also supports the view that ethical AI competence can be taught in a structured manner when learning objectives, instructional tasks, and assessment criteria are clearly aligned (Branch, 2009; Miao & Holmes, 2023).

The usability of the developed micro-credential, as measured through participant responses, is presented in Table 5.

Table 5. System Usability Scale (SUS) Summary.

Usability Indicator	Mean Score	Interpretation	Practical Implication
Ease of use	4.21	Good	Participants were able to navigate the micro-credential with relatively little difficulty
Clarity of learning flow	4.18	Good	Module sequence was understandable and manageable
Task comprehensibility	4.09	Good	Activities and instructions were generally clear
Relevance of interface support	4.02	Good	Platform features supported learning tasks adequately
Overall user confidence	4.15	Good	Participants felt confident in completing the learning process
Overall SUS score	78.4	Acceptable to good usability	The micro-credential demonstrated practical usability for pilot implementation

The results in Table 5 show that the developed micro-credential achieved an acceptable to good usability level, indicating that the learning flow, interface, and task structure were generally well received by participants. Participants reported that the materials were understandable, the activities were relevant, and the combination of modules and reflective tasks supported active engagement. Nevertheless, several responses also suggested the need for minor refinements, such as improving navigation clarity, reducing information density in some sections, and providing more concrete classroom examples. These suggestions are valuable because they highlight opportunities to further improve the learning experience without undermining the fundamental quality of the design.

Discussion

The findings of this study demonstrate that the development of an Ethical AI Micro-Credential is both timely and feasible in pre-service teacher education. The study responds to a growing educational need: the necessity of preparing future teachers not only to use AI tools, but also to understand their implications and apply them responsibly. The results confirm that ethical AI competence should be treated as an integrated capability combining knowledge, judgment, pedagogy, and professional responsibility (Arifin & Kurniawati, 2025).

One important contribution of this study lies in its human-centered orientation. Many current discussions of AI readiness in education still focus primarily on digital efficiency, tool adoption, or technical skills. By contrast, the present study shows that pre-service teachers need a framework that encourages them to evaluate AI use in relation to fairness, learner agency, inclusivity, and instructional consequences. This shift is important because the educational significance of AI does not lie only in what the technology can do, but also in how teachers decide to use it in real pedagogical situations (Siddiqui et al, 2025).

Another important contribution concerns the use of micro-credentials as an instructional strategy. The findings suggest that micro-credentials can serve as an effective format for

developing emerging competencies that may not yet be fully accommodated in formal teacher education curricula. Their modularity, flexibility, and competency-based structure make them especially suitable for rapidly evolving areas such as ethical AI (Brown et al., 2021; Council of the European Union, 2022; Varadarajan et al., 2023). In this study, the micro-credential format enabled a focused and assessable learning pathway that could be integrated into teacher preparation without requiring an immediate redesign of the broader curriculum. This supports the potential of micro-credentials as an innovation mechanism in higher education, particularly for professional and vocationally oriented programs.

The validation and implementation results also indicate that instructional quality depends not only on content selection, but on the coherence between competencies, learning tasks, and assessment evidence. The expert feedback highlighted the importance of contextualizing ethical AI issues through realistic teaching scenarios, while the participant responses showed that applied and reflective tasks were more meaningful than purely conceptual materials. This finding reinforces the principle that competence in ethical AI should be demonstrated through judgment and action, not only through declarative knowledge (Aiken, 1985; Branch, 2009).

Despite these positive findings, the study has several limitations. The implementation was conducted within a relatively short period of two weeks, which restricted the ability to examine long-term retention and sustained behavioral change. In addition, the study was carried out within a single institutional context, meaning that broader generalization should be approached with caution. Future studies may therefore extend the implementation period, involve multiple teacher education institutions, and examine how ethical AI micro-credentials function across subject specializations and institutional settings.

Even with these limitations, the study contributes a validated and practical framework for strengthening AI-related competence in teacher education. The results suggest that the proposed micro-credential can function not only as a learning innovation, but also as a strategic response to the evolving demands of educational transformation. In this sense, the study offers both a conceptual and practical contribution by showing how ethical AI competence can be systematically designed, validated, and introduced into pre-service teacher education through a human-centered micro-credential model.

4. CONCLUSION

This study concludes that the development of an Ethical AI Micro-Credential for pre-service teachers provides a relevant and timely response to the growing need for responsible AI integration in teacher education. Through an R&D approach based on the ADDIE model, the study produced a micro-credential design that integrates ethical reasoning, AI literacy, prompt design, data awareness, inclusive pedagogy, and responsible classroom decision-making into a coherent competency framework.

The findings indicate that the developed micro-credential achieved acceptable content validity, demonstrated practical usability, and contributed positively to participants' understanding of ethical AI in educational contexts. These results suggest that ethical AI competence can be systematically developed when instructional design, assessment evidence, and human-centered pedagogical principles are aligned. The study also shows that micro-credentials can function as a flexible and competency-based pathway for strengthening emerging professional capacities that are not yet fully accommodated in conventional teacher education curricula.

The main contribution of this study lies in reframing AI competence in teacher education not merely as technical proficiency, but as an ethically grounded pedagogical capability. In this respect, the proposed micro-credential offers both conceptual and practical value for preparing future teachers to engage with AI critically, responsibly, and in ways that protect learner agency, fairness, and educational integrity.

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