

Pedagogical Innovation to Enhance Ethics Literacy of Pre-service Teachers within the Post Digital Citizenship Context

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Abstract: This research aimed to: (1) investigate the existing problems, needs, and theoretical foundations related to ethics literacy among pre-service teachers within the context of post-digital citizenship; (2) develop a pedagogical innovation to enhance ethics literacy; and (3) evaluate its effectiveness. The study employed a Research and Development (R&D) methodology consisting of four phases: investigating needs and theoretical foundations, developing the innovation, implementing the innovation, and evaluating its effectiveness. Participants included 266 individuals comprising key informants, experts, pre-service teachers, and stakeholders involved in teacher education. Data were collected through interviews, questionnaires, expert evaluations, ethics literacy assessments, and satisfaction surveys. Quantitative data were analyzed using descriptive statistics, while qualitative data were analyzed through content analysis. The findings revealed that pre-service teachers perceived a high need for ethics literacy development in response to the challenges of the post-digital era. The pedagogical innovation developed through the 5E Approach consisted of four instructional units: Exploring, Ethical Reasoning, Enacting Responsibility, and Embedding Findings. Expert evaluation indicated that the innovation demonstrated high levels of appropriateness, feasibility, and usefulness. Following implementation, participants showed a high level of ethics literacy across cognitive, affective, and behavioral dimensions. In addition, overall satisfaction with the innovation was at a high level. The study concludes that the proposed pedagogical innovation effectively enhances ethics literacy among pre-service teachers and provides a practical framework for integrating ethical learning into teacher education within post-digital citizenship contexts.

Keywords: Pedagogical Innovation, Ethics Literacy, Pre-Service Teachers, Post Digital Citizenship.

1. Introduction

The rapid integration of digital technologies has transformed contemporary societies and educational environments, leading scholars to characterize the current era as a post-digital society. Unlike earlier perspectives that viewed digital technologies as external tools, the post-digital perspective recognizes that digital technologies have become deeply embedded in everyday social, cultural, and educational practices (Jandrić et al., 2018; Knox, 2019). Recent scholarship further suggests that post-digital citizenship extends beyond technological participation and emphasizes critical awareness, ethical engagement, and responsible action within increasingly interconnected socio-technical environments (Örtengren, 2024). Individuals continuously interact with digital systems that influence communication, learning, decision-making, and social participation. Consequently, educational institutions are expected to prepare learners not only with technological competencies but also with the capacity to critically and ethically engage with increasingly complex socio-technical environments. In response to these developments, UNESCO (2021) emphasized the importance of promoting human-centered and ethical approaches to technology use, particularly in relation to emerging technologies and artificial intelligence. Recent UNESCO guidance also highlights the growing influence of generative artificial intelligence in education and emphasizes the need for educators to develop ethical competencies for the responsible use of AI in teaching and learning processes (Holmes & Miao, 2023). Within post-digital societies, responsible participation requires individuals to demonstrate critical awareness, ethical judgment, and social responsibility when navigating technology-mediated contexts. These changing conditions have generated new expectations for education systems and teacher preparation programs, highlighting the need to cultivate ethical competencies that support responsible citizenship and professional practice in an increasingly interconnected world.

Within the context of post-digital societies, ethics literacy has emerged as a crucial competency for responsible participation in increasingly complex technological environments. Ethics literacy refers to the ability to recognize ethical issues, critically evaluate alternative perspectives, make informed moral judgments, and act responsibly in personal, professional, and social contexts (Tuana, 2007). Beyond understanding ethical principles, ethics literacy emphasizes the practical application of ethical reasoning to real-world situations and the capacity to reflect on the consequences of one's decisions. As emerging technologies continue to influence educational practices and human interactions, ethical considerations have become increasingly important in addressing issues related to responsibility, fairness, transparency, and human well-being. Floridi et al. (2018) argued that the development and use of advanced technologies should be guided by ethical principles that protect human dignity and promote social good. The growing adoption of generative artificial intelligence in education has further highlighted the importance of ethics literacy, as educators are increasingly required to evaluate issues related to transparency, accountability, academic integrity, and responsible AI use in teaching and learning contexts (Holmes & Miao, 2023). Consequently, ethics literacy is increasingly recognized as an essential competency that enables individuals to engage critically and responsibly with technological innovations while balancing technological opportunities with fundamental human values.

Teacher education institutions play a critical role in preparing future educators to respond to the ethical and professional challenges of post-digital societies. In addition to pedagogical knowledge and instructional skills, pre-service teachers are increasingly expected to demonstrate ethical awareness, professional responsibility, and the ability to make informed decisions in technology-mediated educational environments. The European Framework for the Digital Competence of Educators highlights that effective teaching in contemporary contexts requires educators to integrate digital competence with responsible and ethical professional practice (Redecker, 2017). Furthermore, recent research emphasizes that teacher education should foster professional digital competence that enables future teachers to critically evaluate the social and ethical implications of educational technologies and support responsible digital citizenship among learners (Örtengren & Olofsson, 2024). This expectation is closely aligned with contemporary perspectives on digital citizenship, which emphasize ethical participation, critical thinking, civic responsibility, and informed engagement in digital environments (Choi, 2016). Consequently, ethics literacy has become an essential component of teacher preparation because it equips pre-service teachers with the capacity to engage in reflective practice, exercise professional judgment, and promote responsible participation in increasingly complex educational environments.

Although previous studies have examined ethics education, digital citizenship, and teacher preparation separately, limited research has developed and empirically evaluated pedagogical innovations specifically designed to enhance ethics literacy among pre-service teachers within post-digital citizenship contexts. Furthermore, few studies have integrated ethical reasoning, reflective practice, and responsible digital participation into a comprehensive pedagogical framework for teacher education. Moreover, limited research has examined how ethics literacy can be systematically developed through pedagogical innovation within post-digital citizenship contexts, particularly among pre-service teachers. Therefore, this study addresses this gap through the development and evaluation of the 5E Approach to Enhancing Ethical Literacy for Pre-Service Teachers in the Context of Post-Digital Citizenship. The study seeks to provide an evidence-based pedagogical framework that supports the development of ethical awareness, reflective thinking, and responsible participation among future teachers in increasingly complex post-digital societies. Accordingly, the objectives of this study were to investigate the needs and theoretical foundations for ethics literacy development, develop a pedagogical innovation based on the 5E Approach, examine its effectiveness in enhancing ethics literacy among pre-service teachers, and evaluate the quality of the developed innovation within the context of post-digital citizenship.

2. Literature Review

2.1. Ethics Literacy in Teacher Education

Ethics literacy has become an essential competency in teacher education due to the increasing complexity of contemporary educational environments. Ethics literacy refers to the ability to recognize ethical issues, critically evaluate competing values, make informed moral judgments, and act responsibly in professional and social contexts (Tuana, 2007). Beyond understanding ethical principles, ethics literacy

emphasizes the practical application of ethical reasoning to real-world situations. In teacher education, ethics literacy is particularly important because teachers function as both educators and moral role models. They are expected to guide learners in addressing ethical issues related to academic integrity, diversity, inclusion, privacy, and responsible technology use. The rapid expansion of artificial intelligence, social media, and digital learning environments has intensified these challenges and created new ethical concerns involving misinformation, algorithmic bias, digital identity, and data protection (UNESCO, 2021). Recent studies have further emphasized that educators require ethical competencies to critically evaluate the opportunities and risks associated with artificial intelligence in educational contexts, including issues related to transparency, accountability, human agency, and responsible decision-making (Holmes, Bialik & Fadel, 2019).

Recent studies suggest that ethics literacy comprises four interrelated dimensions: ethical awareness, ethical reasoning, reflective thinking, and responsible action. Ethical awareness enables individuals to identify ethical dilemmas, while ethical reasoning supports the evaluation of alternative courses of action. Reflective thinking encourages critical examination of personal beliefs and values, and responsible action emphasizes the practical implementation of ethical decisions (Rest et al., 1999). Consequently, ethics literacy has become a critical component of teacher professionalism and an important educational outcome for pre-service teacher preparation programs.

2.2. Post-Digital Citizenship

The emergence of post-digital society has transformed traditional understandings of citizenship and educational participation. While digital citizenship originally focused on responsible technology use, online behavior, and digital literacy, contemporary perspectives argue that digital and physical realities are now deeply interconnected (Choi, 2016). The concept of post-digital citizenship recognizes that technologies such as artificial intelligence, social media, and algorithmic systems have become embedded within everyday social, cultural, and educational practices (Jandrić et al., 2018). Consequently, citizenship in the post-digital era requires not only technical competence but also ethical awareness, critical reflection, and responsible participation in digitally mediated environments. For pre-service teachers, post-digital citizenship is particularly significant because future educators are expected to prepare learners to navigate complex socio-technical realities. This responsibility includes promoting media literacy, ethical technology use, digital rights and responsibilities, and critical engagement with information. Furthermore, teachers must understand how emerging technologies influence issues of equity, inclusion, privacy, and social justice (Örtengren, 2024). Therefore, post-digital citizenship provides an important conceptual framework for developing ethically responsible teachers capable of responding to the challenges of contemporary digital societies.

From a post-digital perspective, ethical challenges no longer emerge solely from online environments but from the continuous entanglement of digital and physical realities. In post-digital societies, individuals simultaneously inhabit algorithmically mediated, datafied, and socially networked spaces where distinctions between online and offline experiences become increasingly blurred (Jandrić et al., 2018). Consequently, ethics literacy requires more than knowledge of moral principles; it

involves the ability to critically interpret socio-technical systems, evaluate algorithmic influences, and exercise responsible judgment in contexts shaped by artificial intelligence, platform governance, and data-driven decision-making. This perspective reframes ethics literacy as a fundamental competency for navigating contemporary educational environments.

2.3. Pedagogical Innovation and the 5E Approach

Pedagogical innovation refers to the development of instructional approaches that enhance learners' knowledge, skills, values, and professional competencies through meaningful learning experiences. Contemporary educational research highlights active learning, experiential learning, collaborative inquiry, and reflective practice as important strategies for promoting deeper understanding and learner engagement (Darling-Hammond et al., 2020). Within teacher education, pedagogical innovation is particularly important for ethics literacy development because ethical competencies cannot be effectively cultivated through lecture-based instruction alone. Instead, learners must actively engage with authentic ethical dilemmas, explore multiple perspectives, and apply ethical principles in realistic situations. Drawing upon constructivist learning theory, experiential learning theory, and reflective practice, this study proposes the 5E Approach to Enhancing Ethical Literacy for Pre-Service Teachers in the Context of Post-Digital Citizenship. The model consists of five interconnected stages: Encountering Critical Situations, Exploring Multiple Perspectives, Ethical Reasoning and Reflection, Enacting Responsibility, and Evaluating and Embedding Values. Through these stages, learners engage in ethical inquiry, reflective dialogue, and responsible action, thereby strengthening ethical awareness, reasoning, reflection, and professional responsibility. The 5E Approach therefore serves as a pedagogical innovation that integrates ethics literacy and post-digital citizenship into a coherent instructional framework for teacher education.

Beyond its instructional function, the 5E Approach may be understood as a pedagogical response to the ethical uncertainties characterizing post-digital societies. Contemporary educators increasingly confront complex ethical dilemmas arising from artificial intelligence, algorithmic decision-making, data surveillance, misinformation, and the erosion of traditional boundaries between online and offline life. These conditions create what may be described as a post-digital ethical crisis, in which established moral frameworks are often insufficient to address emerging socio-technical challenges. Consequently, the 5E Approach was designed not merely as a teaching strategy but as a pedagogical framework that enables pre-service teachers to critically examine competing values, engage in ethical reflection, and develop responsible professional judgment within increasingly complex educational environments (Biesta, 2021).

2.4. Conceptual Framework

Figure 1 presents the conceptual framework integrating post-digital citizenship, pedagogical innovation, and the 5E Approach to enhance ethics literacy among pre-service teachers.

Figure 1: Conceptual Framework of the Study.



2.5. Research Gap

Although previous studies have examined ethics education, digital citizenship, and teacher preparation, these areas have often been investigated independently. Existing research primarily emphasizes digital competence and digital citizenship, while limited attention has been given to ethics literacy development among pre-service teachers within post-digital contexts. Furthermore, few studies have developed and empirically evaluated pedagogical innovations that integrate ethical reasoning, reflective practice, and responsible digital participation into a unified instructional framework. Therefore, this study addresses this gap through the development and evaluation of the 5E Approach to Enhancing Ethical Literacy for Pre-Service Teachers in the Context of Post-Digital Citizenship.

Existing studies have primarily focused on digital citizenship competencies, digital literacy, and teacher professional ethics as separate domains. Limited research has developed pedagogical innovations that systematically integrate ethics literacy, post-digital citizenship, and AI-related ethical challenges within a unified instructional framework for pre-service teachers. Furthermore, empirical evidence regarding the effectiveness of such innovations remains scarce, particularly in Southeast Asian teacher education contexts. This study therefore seeks to address these gaps by developing and evaluating the 5E Approach to Enhancing Ethical Literacy for Pre-Service Teachers in the Context of Post-Digital Citizenship.

3. Research Methodology

3.1. Research Design

This study employed a Research and Development (R&D) approach to develop

and evaluate a pedagogical innovation aimed at enhancing ethics literacy among pre-service teachers within the context of post-digital citizenship. The research process consisted of four phases: (1) needs assessment and theoretical synthesis, (2) innovation development and expert validation, (3) implementation of the innovation, and (4) evaluation of outcomes. The study integrated both qualitative and quantitative methods to ensure the validity and effectiveness of the proposed pedagogical innovation.

3.2. Participants

A total of 266 participants were involved across four phases of the study.

Needs Assessment Phase: 185 pre-service teachers from five universities in Northern Thailand, including Suan Dusit University (Lampang Center), Chiang Mai University, Chiang Mai Rajabhat University, Chiang Rai Rajabhat University, and Lampang Rajabhat University, participated through voluntary sampling.

Expert Validation Phase: Nine experts in teacher education, ethics education, curriculum development, and social studies education were purposively selected to evaluate the quality and content validity of the innovation.

Implementation Phase: Thirty-six pre-service teachers from the Faculty of Education, Suan Dusit University (Lampang Center), participated in the implementation of the innovation.

Evaluation Phase: The same group of 36 participants was involved in evaluating the effectiveness and satisfaction associated with the innovation.

3.3. Research Instruments

Five research instruments were employed:

1. A needs assessment questionnaire examining challenges and requirements related to ethics literacy development.
2. A document analysis form used to synthesize theoretical foundations and relevant literature.
3. An expert evaluation form assessing the appropriateness, feasibility, and usefulness of the innovation.
4. An ethics literacy assessment measuring ethical awareness, ethical reasoning, reflective thinking, and responsible action.
5. A satisfaction questionnaire evaluating participants' perceptions of the learning experience.

Content validity of the instruments was verified by experts using the Item-Objective Congruence (IOC) technique prior to implementation.

3.4. Data Collection

Data collection was conducted in four sequential phases.

First, a needs assessment survey and literature synthesis were conducted to identify the challenges and requirements associated with ethics literacy development in post-digital educational contexts. Second, findings from the first phase were utilized to design the pedagogical innovation based on the 5E Approach. The innovation and instructional plans were subsequently reviewed and validated by experts. Third, the

innovation was implemented with 36 pre-service teachers through four instructional units focusing on ethical issues associated with post-digital citizenship, including artificial intelligence, digital participation, ethical decision-making, and professional responsibility. Finally, participants completed the ethics literacy assessment and satisfaction questionnaire following the implementation period in order to evaluate learning outcomes and instructional effectiveness.

3.5. Data Analysis

Qualitative data derived from document analysis and expert feedback were analyzed using thematic synthesis to identify key concepts and patterns related to ethics literacy and post-digital citizenship.

Quantitative data were analyzed using descriptive statistics, including frequency, percentage, mean, and standard deviation. These analyses were employed to examine needs assessment results, expert evaluations, ethics literacy outcomes, and participant satisfaction levels.

3.6. Ethical Considerations

This research was conducted in accordance with internationally accepted ethical standards for research involving human participants and was approved by the Research Ethics Committee of Chiang Mai University (Approval No. CMUREC 69/085). Prior to data collection, all participants received detailed information regarding the purpose of the study, research procedures, potential benefits, and their rights as research participants. Written informed consent was obtained from all participants. Participation was voluntary, and participants were free to withdraw at any stage without consequences. Confidentiality and anonymity were maintained throughout the study, and all data were securely stored and used exclusively for academic research purposes.

4. Results

In this research, the researcher classified the data obtained from the study and presented the research results according to the stated objectives. The results of the research can be summarized as follows:

4.1. Needs Assessment for Ethics Literacy Development

Table 1: presents the findings from the needs assessment conducted among 185 pre-service teachers. Overall, participants perceived the current challenges related to ethics literacy development at a high level ($M = 4.11$, $SD = 1.01$), while the need for instructional improvement was reported at the highest level ($M = 4.58$, $SD = 0.64$). The three dimensions with the highest levels of need were Curriculum and Content Integration ($M = 4.66$, $SD = 0.58$), Pedagogical Models and Instructional Methods ($M = 4.64$, $SD = 0.65$), and Learning Environments and Resources ($M = 4.60$, $SD = 0.63$). These findings indicate a strong demand for innovative instructional approaches that integrate ethical reasoning, digital responsibility, and post-digital citizenship into teacher education.

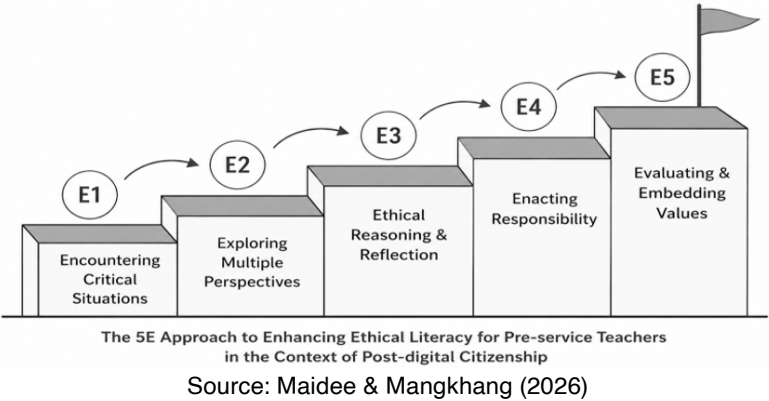
Table 1: Summary of Needs Assessment Results.

Dimension	Current Challenges	Necessities
1. Curriculum & Content Integration	4.04	4.66
2. Instructor Competencies	3.70	4.58
3. Pedagogical Models	4.08	4.64
4. Learning Environment	4.26	4.60
5. Future Teacher Competencies	4.46	4.44
Overview	4.11	4.58
Source: Maidee & Mangkhang (2026)		

4.2. Development of the 5E Pedagogical Innovation

Findings from the needs assessment and documentary analysis led to the development of the pedagogical innovation entitled “The 5E Approach to Enhancing Ethical Literacy for Pre-Service Teachers in the Context of Post-Digital Citizenship.” The innovation was designed around five sequential stages: Encountering, Exploring, Ethical Reasoning and Reflection, Enacting Responsibility, and Evaluating and Embedding. The framework addressed five major themes identified during the analysis process, including ethical challenges associated with artificial intelligence, multicultural diversity, digital citizenship, global responsibility, and professional ethics in teacher education.

Figure 2: Presents the Conceptual Structure of the 5E Approach.



4.3. Expert Validation of the Innovation

The pedagogical innovation was evaluated by nine experts in teacher education, ethics education, and curriculum development. The overall quality of the innovation was rated at a high level ($\bar{x} = 4.47$, $SD = 0.83$), indicating that the instructional framework was appropriate for implementation in teacher education programs. The highest-rated aspects included theoretical accuracy and relevance to teacher ethics ($\bar{x} = 4.89$, $SD = 0.33$), coverage of post-digital ethical issues ($\bar{x} = 4.67$, $SD = 0.71$), and the use of ethical dilemmas and case-based learning to support ethical decision-making ($\bar{x} = 4.67$, $SD = 0.71$). These findings suggest that the innovation successfully integrates ethics literacy and post-digital citizenship within a coherent pedagogical framework.

Table 2: Expert Evaluation of the Innovation.

Dimension	$\bar{x}$	SD
1. Content accuracy.	4.89	0.33
2. Post-digital ethics coverage	4.67	0.71
3. Case-based ethical decision making	4.67	0.71
4. Critical analysis activities	4.56	0.73
5. Responsible digital citizenship	4.56	0.73
Overview	4.47	0.83
Source: Maidee & Mangkhang (2026)		

4.4. Ethics Literacy Outcomes and Student Satisfaction

Following implementation with 36 pre-service teachers, the overall level of ethics literacy was rated at the highest level ($\bar{x} = 4.53$, $SD = 0.66$). Among the five dimensions, Critical Thinking and Digital Ethics demonstrated the highest score ($\bar{x} = 4.70$, $SD = 0.48$), followed by Global Citizenship Engagement ($\bar{x} = 4.63$, $SD = 0.51$) and Professional Ethical Decision-Making. These findings suggest that participation in the 5E learning process enhanced students' ability to critically evaluate ethical issues, engage responsibly in digital environments, and make informed professional decisions.

Student satisfaction toward the pedagogical innovation was also reported at a high level, indicating positive perceptions regarding learning activities, relevance of content, and opportunities for ethical reflection. Participants particularly valued authentic ethical dilemmas, AI-related case studies, and collaborative reflection activities that connected professional ethics with real-world post-digital challenges. This finding supports the argument that ethics literacy can be strengthened through active, inquiry-based, and reflective pedagogical approaches.

Among the dimensions, Critical Thinking and Digital Ethics received the highest score ($\bar{x} = 4.70$), suggesting that participants developed a stronger ability to critically evaluate ethical implications associated with AI technologies, digital media, and information credibility. Similarly, Global Citizenship Engagement ($\bar{x} = 4.63$) reflected participants' increased awareness of social responsibility and ethical participation within interconnected digital communities.

Table 3: Ethics Literacy Outcomes.

Dimension	$\bar{x}$	SD
1. Self & Social Responsibility	4.33	0.77
2. Empathy & Diversity	4.37	0.81
3. Critical Thinking & Digital Ethics	4.70	0.48
4. Academic Integrity & Intellectual Property	4.53	0.75
5. Professional Ethical Decision Making	4.60	0.66
6. Global Citizenship Engagement	4.63	0.51
Overview	4.53	0.66
Source: Maidee & Mangkhang (2026)		

4.5. Reflective Evidence of Ethics Literacy Development

Reflective journals submitted by participants revealed noticeable changes in ethical awareness and professional responsibility. Several participants reported that the

learning activities helped them recognize ethical implications associated with artificial intelligence, academic integrity, and responsible online communication. Others indicated that engaging with authentic ethical dilemmas encouraged them to reconsider their personal values and professional responsibilities as future teachers. These reflections provide qualitative support for the quantitative findings and suggest that the 5E Approach contributed to meaningful ethical engagement beyond cognitive understanding.

5. Discussion

The findings of this study contribute to the growing international discourse on ethics education, digital citizenship, and teacher preparation in post-digital societies. Unlike earlier approaches that treated ethics, digital literacy, and professional identity as separate domains, the present study demonstrates that ethics literacy can be systematically developed through pedagogical innovation specifically designed for the realities of post-digital citizenship.

First, the findings revealed that pre-service teachers perceived both significant challenges and urgent needs regarding ethics literacy development. This result reflects a broader transformation occurring in contemporary education. In post-digital societies, the distinction between online and offline experiences has become increasingly blurred, resulting in ethical dilemmas that extend beyond traditional classroom boundaries. Ethical decisions made by teachers now occur simultaneously across physical classrooms, social media spaces, artificial intelligence platforms, and data-driven educational environments (Williamson, Bayne & Shay, 2020). Consequently, ethics literacy can no longer be understood merely as knowledge of moral principles; rather, it must be viewed as the capacity to critically interpret, evaluate, and respond to complex socio-technical situations. This finding supports recent post-digital scholarship suggesting that educators require ethical competencies capable of addressing algorithmic bias, misinformation, digital surveillance, and responsible AI use within educational contexts (Dignum, 2019). As artificial intelligence increasingly influences educational decision-making processes, teachers must be prepared to critically evaluate the ethical implications of algorithmic systems and exercise professional judgment within complex socio-technical environments.

Second, the development of the 5E Approach to Enhancing Ethical Literacy provides an important pedagogical response to what may be described as a contemporary ethical challenge in teacher education. Existing ethics education frequently emphasizes abstract moral concepts, while offering limited opportunities for learners to engage with authentic ethical dilemmas. The 5E Approach addresses this limitation by integrating ethical inquiry, reflective practice, responsible action, and value internalization into a coherent learning process. Rather than functioning solely as an instructional technique, the model represents a pedagogical framework through which pre-service teachers can negotiate competing values and ethical tensions emerging within post-digital environments. The stages of Encountering, Exploring, Ethical Reasoning and Reflection, Enacting Responsibility, and Evaluating and Embedding collectively create opportunities for learners to move beyond passive ethical awareness toward active ethical engagement and professional responsibility.

Third, the implementation findings demonstrated high levels of ethics literacy among participants across dimensions related to ethical awareness, ethical reasoning, reflective

thinking, and responsible action. These outcomes suggest that ethics literacy development is most effective when learners actively engage with realistic ethical situations rather than merely studying ethical theories. The findings further indicate that issues such as AI ethics, multicultural understanding, digital responsibility, and global citizenship can serve as powerful catalysts for ethical reflection when incorporated into experiential learning activities. Importantly, the results suggest that ethical competence is not developed through isolated knowledge acquisition but through continuous interaction between personal values, professional identity, and social responsibility.

Nevertheless, the findings should be interpreted with caution. Although the innovation produced positive outcomes, the intervention was implemented within a relatively short instructional period of twelve hours. Ethical development and value internalization are inherently longitudinal processes that extend beyond short-term educational interventions. Therefore, the observed improvements should be understood as an initial enhancement of ethics literacy rather than evidence of fully developed ethical dispositions. Future teacher education programs may consider integrating the 5E Approach throughout multiple years of professional preparation to support sustained ethical growth and long-term behavioral transformation.

The findings also carry significant implications for teacher education internationally. While the study was conducted within the Thai context, many of the ethical challenges identified are increasingly global in nature. Issues related to generative artificial intelligence, algorithmic decision-making, information credibility, digital identity, online participation, and social responsibility transcend national boundaries. Consequently, the proposed 5E Approach may provide a transferable framework adaptable to diverse cultural and educational contexts. This finding reinforces contemporary calls for globally relevant teacher education frameworks capable of preparing educators to respond to ethical challenges emerging from artificial intelligence, datafication, and digital transformation. As educational systems worldwide continue to integrate AI technologies into teaching and learning, ethics literacy becomes increasingly important as a core component of professional teacher preparation. The model aligns with UNESCO's recommendations on the ethical use of artificial intelligence in education and contributes to international efforts aimed at preparing educators who can navigate the ethical complexities of technologically mediated societies. As educational systems continue to integrate AI technologies and digital infrastructures, teacher education institutions worldwide may benefit from embedding ethics literacy as a core component of professional preparation rather than treating it as a supplementary competency.

The findings suggest that teacher education institutions should integrate ethics literacy across curriculum structures rather than limiting ethical learning to standalone courses. The 5E Approach may serve as a practical instructional model for embedding ethical reasoning, AI ethics, and responsible digital participation within professional teacher preparation programs.

Overall, this study suggests that ethics literacy should be positioned as a foundational element of teacher education within post-digital societies. The integration of post-digital citizenship principles with pedagogical innovation offers a promising pathway for preparing future teachers who are not only technologically competent but also ethically responsible, critically reflective, and capable of contributing to sustainable and democratic digital futures.

This study has several limitations. First, the intervention was conducted over a relatively short period of twelve instructional hours, which may not fully capture the long-term development of ethical dispositions. Second, ethics literacy outcomes were primarily measured through self-reported assessments, which may be influenced by social desirability bias. Third, the implementation involved participants from a single teacher education institution, limiting the generalizability of the findings. Future research should employ longitudinal designs, incorporate behavioral indicators of ethical practice, and examine the applicability of the 5E Approach across diverse educational and cultural contexts.

6. Conclusion

This study addressed the growing need to prepare pre-service teachers for the ethical challenges emerging within post-digital societies, where the boundaries between online and offline experiences have become increasingly intertwined. The findings revealed that pre-service teachers require systematic support in developing ethics literacy to navigate complex issues related to artificial intelligence, digital participation, information credibility, multicultural engagement, and professional responsibility.

In response to these challenges, the study developed and evaluated the 5E Approach to Enhancing Ethical Literacy for Pre-Service Teachers in the Context of Post-Digital Citizenship. The findings demonstrated that the innovation was highly appropriate, feasible, and effective in promoting ethics literacy across cognitive, affective, and behavioral dimensions. The model enabled participants to engage with authentic ethical dilemmas, critically examine multiple perspectives, reflect upon professional values, and enact responsible actions within contemporary educational contexts.

Beyond its instructional function, the 5E Approach may be understood as a pedagogical response to the ethical complexities of post-digital society. As educational environments become increasingly shaped by artificial intelligence, algorithmic systems, social media, and data-driven technologies, ethics literacy should be regarded as a foundational component of teacher preparation rather than a supplementary competency. Future teachers require not only technological proficiency but also the capacity to exercise ethical judgment, critical reflection, and social responsibility in rapidly evolving socio-technical environments.

Although this study was conducted within the Thai context, its implications extend beyond national boundaries. The ethical challenges associated with AI, digital citizenship, information integrity, and responsible technology use are increasingly global concerns. Therefore, the proposed 5E Approach offers a potentially transferable framework that may be adapted across diverse cultural and educational settings. Furthermore, the model aligns with international efforts, including UNESCO's emphasis on ethical and human-centered approaches to digital transformation and artificial intelligence in education. In this regard, the 5E Approach may serve as a practical global roadmap for teacher education institutions seeking to integrate ethics literacy, digital citizenship, and responsible AI engagement into professional preparation programs. By fostering ethical awareness, critical reflection, and responsible action, the framework provides a scalable model that can be adapted across diverse cultural and educational contexts while supporting the development of ethically responsible educators for post-digital societies. At the policy level, educational authorities and teacher education institutions

should consider incorporating ethics literacy and responsible AI engagement into teacher competency frameworks. Such efforts may strengthen the preparation of future teachers capable of responding to emerging ethical challenges in post-digital societies.

Nevertheless, ethical development remains a long-term process that cannot be fully achieved through short-term interventions alone. Future research should investigate the long-term impact of ethics literacy development and explore how the 5E Approach can be integrated into multi-year teacher education programs. Such efforts may contribute to the development of a global roadmap for preparing ethically responsible educators capable of leading future generations in increasingly complex post-digital societies.

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