



AI LITERACY AND READINESS AMONG PRE-SERVICE TEACHERS FOR SUSTAINABLE EDUCATION

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1. ABSTRACT

Artificial Intelligence (AI) is rapidly emerging as an influential technology in education, creating new possibilities for teaching, learning, assessment and professional practice. Its increasing presence in educational settings has also generated a growing need to prepare teachers who can understand, evaluate and use AI responsibly. In this context, AI literacy and AI readiness have become important dimensions of contemporary teacher education. The present study focuses on AI literacy and AI readiness among pre-service teachers for sustainable education, with particular attention to the relationship between these two constructs. The study seeks to examine the level of AI literacy and AI readiness among pre-service teachers and to determine whether a significant relationship exists between them. A descriptive and correlational research design will be employed. Data will be collected from selected pre-service teachers enrolled in B.Ed. programmes using a structured questionnaire developed around relevant dimensions of AI literacy and AI readiness. Appropriate descriptive and inferential statistical techniques will be used to analyse the collected data, with the level of significance maintained at 0.05.

The study is grounded in the understanding that effective AI integration in education requires more than technical familiarity with AI tools. Future teachers need conceptual understanding, critical evaluation skills, awareness of ethical concerns, confidence and pedagogical preparedness to use AI appropriately. The study therefore considers AI literacy and AI readiness as related but distinct dimensions of teacher preparedness. Its findings are expected to provide useful insights for strengthening AI-related competencies within teacher education programmes and promoting responsible, inclusive and human-centred use of AI. In the broader context of sustainable education, developing such competencies may help future teachers respond effectively to technological change while maintaining professional judgement, learner-centredness and ethical responsibility.

KEYWORDS: Artificial Intelligence, AI Literacy, AI Readiness, Pre-service Teachers, Teacher Education, Sustainable Education.

2. INTRODUCTION

Artificial Intelligence (AI) has emerged as one of the most influential technological developments of the twenty-first century, with increasing applications across healthcare, business, communication, research and education. In the educational context, AI is no longer limited to experimental or highly specialised applications. AI-supported systems are increasingly being used for content generation, personalised learning, assessment support, language assistance, feedback, educational planning and other academic activities. The rapid expansion of generative AI has further accelerated this transformation by making sophisticated AI capabilities accessible to teachers and learners through relatively simple interfaces. The growing presence of AI in education presents both significant opportunities and complex challenges. AI can support teachers in designing learning materials, generating instructional resources, adapting content to different learner needs and providing timely assistance. It may also facilitate personalised learning and improve accessibility for learners with diverse educational requirements. However, the use of AI also raises concerns related to accuracy, bias, privacy, academic integrity, overdependence on technology, transparency and the appropriate use of learner data. Consequently, the educational value of AI depends not merely on the availability of technological tools but on the competence and judgement of the individuals who use them.

In this changing environment, the role of teachers is particularly important. Teachers are responsible for making pedagogical decisions, interpreting learners' needs and ensuring that technology is used in accordance with educational objectives. Even when AI systems are capable of generating sophisticated responses or instructional materials, teachers remain responsible for evaluating the relevance, accuracy and appropriateness of such outputs. Therefore, preparing teachers for an AI-supported educational environment requires a combination of technological understanding, critical thinking, pedagogical knowledge and ethical awareness. Teacher education has a crucial role in developing these competencies before individuals enter the teaching profession. Pre-service teachers, particularly those enrolled in B.Ed. programmes, represent an important group for understanding the preparedness of the future teaching workforce. Their exposure to AI, understanding of its educational applications and confidence in using AI may influence how effectively they integrate emerging technologies into their future classrooms. If future teachers receive appropriate preparation during their professional education, they may be better positioned to use AI as a supportive resource while maintaining human judgement and professional responsibility.



One of the central concepts in this context is AI literacy. AI literacy extends beyond simply knowing how to operate an AI application. It involves understanding basic AI concepts, recognising its potential applications, critically evaluating AI-generated information, understanding its limitations and being aware of ethical and social implications. For teachers, AI literacy is particularly important because they must be able to distinguish between technically possible uses of AI and educationally appropriate uses of AI. A teacher who possesses adequate AI literacy can make more informed decisions regarding when, why and how AI should be incorporated into teaching and learning. Alongside AI literacy, AI readiness represents another important dimension of teacher preparedness. Knowledge about AI does not automatically ensure that a teacher feels capable or willing to use it in educational practice. AI readiness reflects the extent to which individuals perceive themselves as prepared, confident and willing to engage with AI for appropriate educational purposes. A pre-service teacher may understand the basic principles of AI but may still lack confidence in integrating AI into lesson planning, assessment or classroom activities. Conversely, willingness to use AI without sufficient understanding may lead to inappropriate or uncritical adoption. Examining AI literacy and AI readiness together can therefore provide a more comprehensive understanding of future teachers' preparedness.

The relationship between these two constructs is particularly relevant for teacher education. Adequate AI literacy may contribute to greater confidence and preparedness, while meaningful opportunities to use AI in pedagogical contexts may further strengthen teachers' practical understanding. At the same time, readiness should not be interpreted simply as a willingness to adopt technology. Responsible readiness involves the ability to recognise both the potential benefits and limitations of AI and to make pedagogically and ethically informed decisions about its use. The issue also needs to be considered from the broader perspective of sustainable education. Sustainability in education is concerned not only with technological advancement but also with quality, inclusion, equity, lifelong learning, responsible innovation and the development of educational systems capable of responding to changing social and technological conditions. In this regard, AI can contribute to sustainable education when it is used to enhance learning opportunities, support diverse learners and improve educational processes without compromising human agency, ethical responsibility or educational quality.

A sustainable approach to AI integration therefore requires teachers who can balance technological possibilities with educational and human considerations. The objective should not be to replace teachers with AI or to encourage unrestricted technological adoption. Instead, AI should be positioned as a supportive resource that can complement teachers' professional knowledge and expand educational possibilities. Such an approach requires future teachers to develop the ability to critically examine AI-generated content, protect learner privacy, recognise potential biases, maintain academic integrity and ensure that technological interventions remain aligned with learning objectives. The increasing relevance of these issues has also been recognised internationally. UNESCO's AI Competency Framework for Teachers emphasises the development of teacher competencies related to AI foundations and applications, ethics, human-centred approaches, AI pedagogy and professional learning. This framework reinforces the idea that teachers need broader competencies to engage responsibly with AI rather than merely acquiring technical skills. Such competency-oriented perspectives provide an important foundation for examining the preparedness of pre-service teachers in the context of contemporary teacher education.

Despite the increasing discussion surrounding AI in education, questions remain regarding the extent to which future teachers actually possess the knowledge and preparedness required for meaningful AI integration. Existing research has explored aspects of AI literacy, technology acceptance, AI preparedness and teachers' perceptions of emerging technologies. However, understanding AI literacy and AI readiness together can provide additional insight into whether knowledge and critical understanding are accompanied by perceived preparedness for educational use. The present study is therefore designed to examine AI literacy and AI readiness among pre-service teachers for sustainable education. By focusing on future teachers, the study seeks to understand an important stage of professional preparation at which attitudes, knowledge and competencies related to emerging technologies can still be developed systematically. The study also seeks to examine the relationship between AI literacy and AI readiness, thereby providing evidence that may assist teacher education institutions in designing appropriate AI-related learning experiences. The significance of the study extends beyond the adoption of individual AI tools. As AI continues to evolve, specific applications may change rapidly, but the underlying competencies required to evaluate and use such technologies responsibly are likely to remain important. Preparing teachers to learn, adapt and critically engage with emerging AI systems may therefore be more valuable than training them only in the use of particular platforms.

In this context, strengthening AI literacy and AI readiness among pre-service teachers can contribute to the development of a teaching workforce capable of responding thoughtfully to technological change. Such preparedness can support responsible innovation while ensuring that the fundamental purposes of education-meaningful learning, human development, inclusion, equity and professional responsibility-remain central. The present study consequently seeks to contribute to the emerging discourse on AI in teacher education by examining the preparedness of future teachers through the interconnected perspectives of AI literacy, AI readiness and sustainable education.



3. REVIEW OF RELATED LITERATURE

The growing integration of Artificial Intelligence (AI) into education has generated considerable scholarly interest in understanding the competencies, perceptions and preparedness of teachers and learners. As AI technologies become increasingly accessible, researchers have begun to examine not only the technological possibilities associated with AI but also the knowledge and professional competencies required for its meaningful and responsible use. Within teacher education, particular attention has been given to AI literacy, technological preparedness, confidence, acceptance and the pedagogical integration of AI-based tools. Research on AI literacy generally indicates that technological familiarity alone is insufficient for effective engagement with artificial intelligence. AI literacy encompasses an understanding of fundamental AI concepts, awareness of its applications, the ability to evaluate AI-generated information and recognition of the limitations and ethical implications associated with AI systems. For teachers, these competencies are particularly important because they are expected to guide learners in navigating AI-supported environments and to evaluate whether AI-generated resources are appropriate for particular educational purposes. Consequently, AI literacy is increasingly being viewed as a component of broader digital and professional competence.

Recent studies involving pre-service teachers have reported varying levels of AI-related knowledge and awareness. Ayanwale et al. (2024), for example, examined AI literacy among pre-service teachers and highlighted the importance of developing AI-related competencies before future teachers enter professional practice. Their work suggests that teacher preparation programmes need to move beyond general technological exposure and provide opportunities for future teachers to develop a deeper understanding of AI and its educational implications. The literature also indicates that AI readiness is an important but distinguishable dimension of teacher preparedness. Readiness involves more than awareness of AI; it encompasses confidence, willingness, perceived usefulness and preparedness to employ AI in appropriate educational situations. Bautista et al. (2024), in examining pre-service teachers' readiness to integrate AI-based tools through a TPACK-oriented perspective, emphasised the importance of the interaction between technological knowledge and pedagogical considerations. Their findings reinforce the idea that successful AI integration requires teachers to connect technological possibilities with appropriate teaching strategies rather than treating AI as an isolated technical skill.

The importance of pedagogical preparedness becomes particularly evident when considering the rapid emergence of generative AI. Teachers may have access to powerful systems capable of producing explanations, questions, lesson materials and other educational content, but effective use requires professional judgement. AI-generated outputs may contain inaccuracies, biases or contextually inappropriate information. Thus, teachers need the ability to critically evaluate outputs rather than accepting them automatically. This reinforces the connection between AI literacy and AI readiness: knowledge and critical understanding can provide a foundation for more responsible and confident educational use. Another significant strand of the literature concerns the ethical dimensions of AI in education. The use of AI raises questions about privacy, data protection, algorithmic bias, transparency, academic integrity and human agency. Adam et al. (2023) emphasised the importance of ethical principles when considering artificial intelligence in educational contexts. Such perspectives are particularly relevant to teacher education because future teachers will be responsible for making decisions that affect learners directly. Consequently, AI competency should include ethical and critical dimensions alongside technical knowledge.

International frameworks have further strengthened the competency-based understanding of AI in teacher education. UNESCO's AI Competency Framework for Teachers (Miao & Cukurova, 2024) presents teacher AI competence as a multidimensional construct involving AI foundations and applications, ethics of AI, human-centred approaches, AI pedagogy and professional learning. The framework is significant because it shifts attention from simple technological adoption towards the development of teachers who can engage with AI critically, ethically and pedagogically. It also supports the view that teacher preparation should address both the opportunities and risks associated with AI. The literature further suggests that AI adoption should not be understood simply as a matter of willingness to use technology. A teacher may be highly willing to experiment with AI but may lack the knowledge necessary to evaluate its outputs responsibly. Similarly, a teacher may possess considerable knowledge about AI but may not feel sufficiently confident to integrate it into classroom practice. This distinction provides a strong conceptual basis for examining AI literacy and AI readiness as related but separate constructs.

Within the context of sustainable education, the literature on educational technology increasingly points towards responsible and human-centred technological integration. Technology can contribute to educational sustainability when it improves accessibility, supports diverse learning needs, strengthens learning opportunities and enables teachers to respond effectively to changing educational demands. However, technological innovation does not automatically produce sustainable outcomes. Its educational value depends on how technologies are implemented and whether their use supports broader principles of equity, inclusion, quality and human development. AI therefore needs to be considered as part of a broader educational ecosystem rather than simply as another digital tool. For pre-service teachers, this requires opportunities to explore the educational possibilities of AI while simultaneously examining its limitations and



ethical consequences. Teacher education programmes that develop critical technological understanding may help future teachers avoid both extremes of uncritical enthusiasm and unnecessary resistance towards AI.

Overall, the reviewed literature demonstrates that AI literacy, AI readiness, ethical awareness and pedagogical preparedness are increasingly important components of contemporary teacher competence. Existing studies provide valuable evidence regarding pre-service teachers' AI knowledge, perceptions and preparedness, while international competency frameworks offer broader guidance for responsible AI integration. However, the literature also indicates the need for empirical examination of how AI literacy and AI readiness are related within the specific context of pre-service teacher education, particularly when considered in relation to the broader goal of sustainable education. The present study builds upon this body of literature by bringing these dimensions together within a single empirical framework. Rather than examining AI literacy or readiness in isolation, it seeks to understand their levels and relationship among pre-service teachers. This approach provides a basis for identifying whether stronger AI-related understanding is accompanied by greater perceived preparedness and can generate evidence relevant to the development of more effective, ethical and sustainable approaches to AI integration in teacher education.

4. RESEARCH GAP AND RATIONALE

The review of existing literature indicates that Artificial Intelligence is becoming an increasingly relevant component of contemporary teacher education. Previous studies have examined AI literacy, technological competence, perceptions of AI, preparedness to use AI-based tools and the ethical dimensions of AI integration. These studies collectively suggest that future teachers require more than basic familiarity with AI; they need conceptual understanding, critical awareness, pedagogical preparedness and the ability to make responsible decisions regarding its use. However, the existing literature also reveals an important area requiring further empirical attention. AI literacy and AI readiness are often examined as related but distinct dimensions of technological preparedness. While existing studies have investigated pre-service teachers' knowledge and understanding of AI, and others have explored their willingness or preparedness to integrate AI-based tools, comparatively less attention has been given to examining these two dimensions together within a single empirical framework. In particular, there is a need to understand whether pre-service teachers possessing greater AI literacy also demonstrate greater readiness to employ AI appropriately in educational contexts.

A further gap emerges from the distinction between knowing about AI and being prepared to use AI. Knowledge of AI does not automatically translate into pedagogically meaningful practice. A pre-service teacher may understand basic AI concepts and recognise its educational applications but may still lack confidence in using AI for lesson planning, assessment or learner support. Similarly, willingness to use AI without sufficient knowledge and critical awareness may lead to uncritical dependence on AI-generated information. Examining AI literacy and AI readiness together can therefore provide a more meaningful picture of future teachers' preparedness. The ethical dimension also deserves greater attention. The increasing availability of generative AI creates opportunities for educational innovation but simultaneously raises concerns regarding accuracy, bias, privacy, academic integrity, transparency and human agency. Teacher preparedness should therefore not be understood simply in terms of the ability or willingness to operate AI tools. It should include the capacity to evaluate AI outputs critically and to make decisions that are consistent with professional and ethical responsibilities. This perspective is particularly important for pre-service teachers, who will soon be responsible for guiding learners in increasingly AI-mediated educational environments.

Another relevant consideration is the connection between AI competency and sustainable education. Much of the discussion surrounding educational AI focuses on efficiency, innovation and technological adoption. However, sustainable educational development requires technology to be used in ways that promote inclusion, equity, quality learning, responsible innovation and human development. There remains a need for research that considers future teachers' AI competencies within this broader educational context rather than viewing AI adoption solely as a technological issue. The present study therefore addresses a specific gap by examining AI literacy and AI readiness together among pre-service teachers and considering their significance for sustainable education. The study seeks not merely to determine whether future teachers are familiar with AI, but to examine whether their knowledge and critical understanding are associated with their perceived preparedness to use AI in educational practice.

The rationale for the study is further strengthened by the changing expectations of teacher education. Since AI technologies are likely to continue evolving, teacher preparation cannot be limited to training in particular applications that may quickly become outdated. Instead, future teachers need transferable competencies that enable them to understand emerging AI systems, evaluate their usefulness and limitations, adapt to technological change and make informed pedagogical decisions. Accordingly, empirical evidence regarding the present level of AI literacy and readiness among pre-service teachers can help teacher education institutions identify areas requiring



greater attention. Such evidence may support the development of curriculum components, workshops, practical experiences and professional learning opportunities aimed at developing responsible AI competence.

Thus, the present study is justified by the need to bridge the gap between AI knowledge and AI preparedness, while situating both within the broader objective of sustainable and human-centred education. By investigating the relationship between AI literacy and AI readiness among pre-service teachers, the study seeks to contribute evidence that can inform contemporary teacher education and support more responsible integration of artificial intelligence into future educational practice.

5. OBJECTIVES, RESEARCH QUESTIONS AND HYPOTHESES

Objectives of the Study

The present study aims to :

1. To assess the level of AI literacy among pre-service teachers.
2. To assess the level of AI readiness among pre-service teachers for educational use.
3. To examine the relationship between AI literacy and AI readiness among pre-service teachers.
4. To examine the implications of AI literacy and AI readiness for sustainable education.

Research Questions

The study seeks to answer the following research questions:

1. What is the level of AI literacy among pre-service teachers?
2. What is the level of AI readiness among pre-service teachers for educational use?
3. Is there a significant relationship between AI literacy and AI readiness among pre-service teachers?
4. What are the implications of AI literacy and AI readiness for sustainable education?

Research Hypotheses

The following null hypotheses will be tested at the 0.05 level of significance:

H₀₁: There is no significant relationship between AI literacy and AI readiness among pre-service teachers.

H₀₂: There is no significant difference in AI literacy and AI readiness among pre-service teachers across selected demographic variables.

6. METHODOLOGY

The present study will employ a descriptive and correlational research design to examine AI literacy and AI readiness among pre-service teachers. The descriptive component will help determine the existing level of AI literacy and AI readiness, while the correlational component will examine the relationship between these two constructs. The design is considered appropriate because the study aims to investigate naturally occurring characteristics and relationships without manipulating the study variables. The population of the study will comprise pre-service teachers enrolled in B.Ed. programmes in selected teacher education institutions. A suitable sample will be selected from the identified population using an appropriate sampling procedure based on the accessibility and characteristics of the study setting. The final sample size and demographic characteristics of the respondents will be reported on the basis of the actual data collected. Data will be collected using a structured questionnaire developed specifically for the present study. The instrument will consist primarily of items measuring two principal constructs: AI literacy and AI readiness. AI literacy items will address areas such as understanding of AI concepts, awareness of AI applications, critical evaluation of AI-generated information, recognition of AI limitations and ethical awareness. AI readiness items will focus on confidence, willingness to use AI, perceived usefulness, preparedness for educational integration and responsible use of AI.

A five-point Likert-type scale will be used for the main items, ranging from 1 = Strongly Disagree to 5 = Strongly Agree. Higher scores will indicate comparatively higher levels of the respective construct. The questionnaire will also include selected demographic variables where their inclusion is relevant to the objectives and proposed analysis. The instrument will be developed with reference to relevant empirical literature and established competency frameworks concerning AI in education. Particular consideration will be given to the UNESCO AI Competency Framework for Teachers, which provides a structured understanding of teacher competencies related to AI foundations and applications, ethics, human-centred approaches, AI pedagogy and professional learning. The initial questionnaire will be reviewed by experts in teacher education, educational technology and/or related fields to assess the relevance, clarity and adequacy of the items. Necessary revisions will be made on the basis of expert suggestions.

A pilot study will be conducted with a small group of pre-service teachers who will not form part of the final sample. The pilot administration will help identify ambiguous wording, repetitive items and possible difficulties in responding to the questionnaire. The



internal consistency of the instrument will be assessed using Cronbach's alpha coefficient, and appropriate modifications will be made before final administration. For data collection, the selected participants will be informed about the purpose and academic nature of the study and provided with clear instructions. Participation will be voluntary, and respondents will be encouraged to provide honest responses based on their own understanding and experiences. Confidentiality of responses will be maintained, and the collected information will be used only for academic and research purposes. The completed responses will be screened for completeness, coded and organised for statistical analysis.

The collected data will be analysed using appropriate descriptive and inferential statistical techniques. Frequency, percentage, mean and standard deviation will be used to describe the data and determine the levels of AI literacy and AI readiness. Pearson's product-moment correlation coefficient (r) will be used to examine the relationship between AI literacy and AI readiness, subject to the fulfilment of relevant assumptions. Where comparisons across selected demographic groups are justified by the research objectives, an appropriate t-test or one-way ANOVA will be employed. The level of significance will be maintained at 0.05. The methodological procedure will thus provide a systematic basis for examining the study variables and testing the proposed hypotheses. Importantly, actual sample characteristics, reliability coefficients and statistical findings will be reported only after the empirical data have been collected and analysed, thereby ensuring that the study remains evidence-based and avoids unsupported or fabricated results.

7. RESULTS AND DISCUSSION

The data collected through the research instrument will be analysed and interpreted in accordance with the objectives and hypotheses of the study. The results will first present the overall levels of AI literacy and AI readiness among pre-service teachers, followed by an examination of the relationship between the two major constructs. Where demographic comparisons are included, they will be interpreted only when they are relevant to the research objectives and supported by the collected data. Descriptive statistics, including mean and standard deviation, will be used to determine the overall pattern of responses. The findings will help indicate whether pre-service teachers demonstrate relatively higher or lower levels of AI literacy and AI readiness. The interpretation will focus not merely on numerical scores but also on what these scores imply for the preparedness of future teachers to engage with AI in educational contexts. The relationship between AI literacy and AI readiness will constitute a central component of the analysis. The Pearson product-moment correlation coefficient will be used to determine the direction and strength of the relationship between the two variables. The statistical significance of the obtained correlation will be examined at the 0.05 level of significance. The relevant null hypothesis will consequently be accepted or rejected on the basis of the actual statistical evidence. The discussion of the findings will be developed in relation to the existing literature. If a positive relationship is found between AI literacy and AI readiness, it may suggest that greater understanding and critical awareness of AI are associated with greater perceived preparedness to use AI for educational purposes. Such a finding would reinforce the importance of developing AI knowledge alongside practical and pedagogical opportunities during teacher preparation. If the relationship is weak or non-significant, however, it would indicate that knowledge alone may not necessarily translate into readiness and that other factors, such as institutional support, prior exposure, confidence, access to technology or pedagogical experience, may also influence preparedness.

The findings will also be examined from an ethical and pedagogical perspective. A higher level of readiness should not simply be interpreted as a greater willingness to adopt AI tools. Meaningful readiness involves the ability to evaluate AI-generated information, recognise limitations and biases, protect privacy, maintain academic integrity and make decisions based on educational objectives. Therefore, the quality of AI integration will depend on the extent to which future teachers can combine technological awareness with professional judgement. The results will further be interpreted in the context of sustainable education. AI may contribute to sustainable educational practices by supporting accessibility, personalised learning, instructional efficiency and diverse learner needs. However, such benefits depend on responsible implementation. The findings may therefore provide useful evidence regarding the extent to which teacher education programmes are preparing future teachers to engage with AI in ways that are inclusive, ethical, human-centred and educationally meaningful.

Finally, the discussion will compare the empirical findings of the present study with relevant previous research and established AI competency frameworks. Areas of agreement may strengthen existing evidence, while differences may provide opportunities to consider contextual factors influencing pre-service teachers' AI literacy and readiness. The final interpretation will therefore connect the statistical evidence with the broader educational significance of preparing teachers for an increasingly AI-supported learning environment.

8. EDUCATIONAL IMPLICATIONS

The findings of the present study have important implications for teacher education, particularly in the context of preparing future teachers for an increasingly AI-supported educational environment. The study highlights the need to view AI competence as an integral



component of contemporary teacher preparation rather than as an additional technological skill. Pre-service teachers require opportunities to develop both an understanding of AI and the confidence to use it appropriately within pedagogical contexts. Teacher education institutions may consider incorporating structured AI-related learning experiences within B.Ed. programmes. Such experiences should move beyond demonstrations of individual AI tools and focus on developing transferable competencies, including critical evaluation of AI-generated content, awareness of limitations and biases, ethical decision-making, responsible use of learner data and appropriate selection of AI applications according to instructional objectives. This would enable future teachers to make informed decisions rather than adopting AI simply because of its technological novelty.

The findings also have implications for teacher educators. Teacher educators can model responsible AI use by demonstrating how AI may support lesson planning, instructional material development, assessment and differentiated learning while simultaneously encouraging pre-service teachers to verify AI-generated outputs. Classroom discussions, practical activities, case-based learning and reflective tasks can help future teachers understand both the potential and limitations of AI in authentic educational situations. The relationship between AI literacy and AI readiness also suggests the importance of connecting knowledge with practical experience. Developing conceptual knowledge without opportunities for application may not be sufficient to build confidence, while practical exposure without critical understanding may encourage uncritical dependence on AI. Teacher preparation should therefore provide a balanced combination of conceptual understanding, guided practice, reflection and ethical consideration.

At the institutional level, teacher education institutions may also need to develop appropriate guidelines for responsible AI use. Such guidelines can address academic integrity, privacy, transparency, bias, appropriate attribution and the role of human judgement in AI-supported educational practices. Clear institutional guidance can help pre-service teachers understand that responsible AI use involves not only what technology can do, but also what it should be used for within a particular educational context. The study further has implications for sustainable education. AI-related teacher preparation should consider inclusion, accessibility, equity and learner well-being alongside technological innovation. When future teachers are equipped to use AI critically and responsibly, the technology can potentially support diverse learning needs and contribute to more flexible and inclusive educational practices. At the same time, maintaining human interaction and teacher agency remains essential for ensuring that technological advancement does not weaken the relational and developmental dimensions of education.

Overall, the study suggests that strengthening AI literacy and AI readiness during pre-service teacher education can contribute to the development of teachers who are capable of adapting to technological change while maintaining professional, ethical and pedagogical responsibility. Such preparation can provide a foundation for responsible, human-centred and sustainable integration of AI in education.

9. LIMITATIONS AND FUTURE RESEARCH

The present study has certain limitations that should be considered while interpreting its findings. First, the study is conducted among pre-service teachers from selected teacher education institutions; therefore, the findings may not be fully generalisable to all pre-service teachers across different geographical regions, institutional settings and educational contexts. Differences in access to technology, exposure to AI, institutional facilities and prior technological experience may influence participants' AI literacy and readiness. Second, the study primarily relies on self-reported responses. Participants' perceptions of their AI literacy and readiness may not always correspond precisely with their actual ability to use AI in authentic teaching situations. A respondent may report high confidence or readiness while having limited practical experience with AI-based educational applications. Future research may therefore combine questionnaire-based data with performance-based tasks, classroom observations, interviews or practical demonstrations of AI use.

Third, AI is a rapidly evolving field. The tools, applications and educational practices available at the time of the study may change considerably as new AI technologies emerge. Consequently, AI literacy and readiness should be understood as developing competencies rather than fixed characteristics. Continued research will be necessary to examine how teachers' competencies and perceptions evolve alongside technological developments. Future studies may address these limitations by employing larger and more diverse samples covering different regions, institutions and teacher education programmes. Longitudinal studies could examine changes in AI literacy and readiness over time, while mixed-method research could provide deeper insight into the experiences, challenges and expectations of pre-service teachers. Experimental and intervention-based studies could further examine whether structured AI training, workshops or curriculum-based interventions significantly improve teachers' AI literacy, confidence and pedagogical readiness.

Further research may also investigate the influence of variables such as prior exposure to AI, digital competence, access to technology, institutional support, teacher educators' preparedness and actual frequency of AI use. Such investigations can provide a more comprehensive understanding of the factors that shape responsible AI integration in teacher education. Future scholarship should also



pay greater attention to the ethical, inclusive and sustainable dimensions of AI-supported education. Research examining privacy, algorithmic bias, accessibility, academic integrity, learner well-being and human agency can help ensure that the growing use of AI contributes to educational improvement without compromising fundamental educational values.

10. CONCLUSION

Artificial Intelligence is increasingly becoming an important part of the contemporary educational environment, influencing teaching, learning, assessment and professional practice. This transformation creates new opportunities for improving educational processes, but it also places new responsibilities on teachers. The effective use of AI in education requires more than access to sophisticated technological tools; it requires teachers who possess adequate knowledge, critical understanding, confidence, ethical awareness and pedagogical judgement. In this context, preparing future teachers for responsible engagement with AI has become an important concern of teacher education. The present study focuses on AI literacy and AI readiness among pre-service teachers for sustainable education. It recognises AI literacy and AI readiness as two closely connected but conceptually distinct dimensions of teacher preparedness. AI literacy provides the foundation for understanding artificial intelligence, recognising its educational applications, critically evaluating AI-generated information, identifying its limitations and considering the ethical implications of its use. AI readiness, in contrast, reflects the extent to which future teachers feel prepared, confident and willing to engage with AI appropriately in educational contexts. Considering these dimensions together provides a broader perspective on the preparedness of pre-service teachers than examining technological awareness alone.

The focus on pre-service teachers is particularly significant because teacher education represents a crucial stage for developing professional competencies before individuals enter the classroom. The knowledge, attitudes and experiences acquired during B.Ed. programmes can influence how future teachers respond to emerging technologies throughout their professional careers. Providing meaningful exposure to AI during teacher preparation can therefore help future teachers develop an informed and balanced approach to technological innovation. Such preparation should not be limited to learning how particular AI tools operate; rather, it should develop the capacity to determine when, why and how AI can be used appropriately for particular educational purposes. The study also highlights the importance of distinguishing between technological adoption and responsible technological integration. A teacher may be willing to use AI without possessing adequate knowledge to evaluate its outputs, while another teacher may understand AI but lack the confidence or practical experience required for educational application. Meaningful AI readiness therefore requires a combination of understanding, confidence, pedagogical preparedness and ethical responsibility. Future teachers should be able to recognise both the possibilities and limitations of AI and make decisions based on learner needs, curriculum objectives and professional values.

The broader perspective of sustainable education further strengthens the significance of the study. Technological innovation contributes to sustainable education only when it supports quality, inclusion, equity, accessibility, lifelong learning and responsible educational development. AI has the potential to assist teachers in creating learning resources, supporting diverse learners, providing instructional assistance and improving aspects of educational practice. However, these possibilities cannot be separated from concerns related to privacy, bias, accuracy, academic integrity, learner dependence and human agency. Sustainable AI integration therefore requires a human-centred approach in which technology complements rather than replaces teachers' professional judgement and relationships with learners. The findings and implications of the study point towards the need for greater attention to AI competency within teacher education programmes. Teacher educators and institutions can create opportunities for pre-service teachers to explore AI through practical activities, critical discussions, pedagogical applications and reflective learning experiences. Such preparation can help future teachers move beyond passive awareness towards active, informed and responsible engagement with AI. It can also enable them to guide their future learners in navigating an increasingly AI-mediated world.

At the institutional level, teacher education programmes may benefit from clear frameworks and guidelines concerning responsible AI use. These may address issues such as academic integrity, privacy, transparency, bias, verification of AI-generated content and appropriate attribution. Establishing such practices during pre-service education can contribute to the development of professional habits that remain relevant as AI technologies continue to evolve. Ultimately, the educational significance of AI will depend not only on the capabilities of the technology but also on the competence, judgement and values of the teachers who use it. Strengthening AI literacy and AI readiness among pre-service teachers can help develop a teaching workforce that is capable of adapting to technological change without losing sight of the fundamental purposes of education. Future teachers need to be prepared not merely to use AI, but to evaluate it critically, employ it ethically and integrate it purposefully in ways that enhance meaningful learning.

Thus, the study contributes to the emerging discourse on AI and teacher education by bringing together the dimensions of AI literacy, AI readiness and sustainable education. Developing these competencies at the pre-service stage can provide a strong foundation for



responsible and inclusive AI integration in educational practice. A balanced approach that combines technological competence with human values, pedagogical understanding and ethical responsibility can ensure that AI serves as a meaningful educational support rather than becoming a substitute for professional teaching. In this way, teacher education can play a decisive role in shaping an educational future in which artificial intelligence is used critically, responsibly, inclusively and sustainably.

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