Empowering Students with AI Literacy: A Scoping Review on Promising Pedagogical Approaches in Post-Secondary Education

by

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ABSTRACT

As artificial intelligence (AI) becomes increasingly integrated into society, AI literacy has emerged as a critical competency. Post-secondary students, in particular, need to be prepared to use, understand, and evaluate AI technologies through a critical lens as they navigate evolving AI-driven landscapes. However, research related to how AI literacy is developed at the post-secondary level is currently underexplored. This scoping review examines current teaching and learning strategies that support post-secondary students' AI literacy development. The findings highlight promising instructional approaches that can be used to inform future AI literacy interventions and reveal gaps in the current literature that warrant further exploration.

Keywords: AI literacy; higher education; post-secondary students; pedagogical practices

AUTHOR'S DECLARATION

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DEDICATION

I dedicate this paper to my former classmates and dear friends, Brenda, Joycelyn, and Roman. Our collaboration throughout the MEd program encouraged me to confidently explore AI-related discourse. And to my family, this dedication is for you as well. Completing this paper marks the end of my Master's degree. This accomplishment holds a special place in my heart, representing the unique legacy of being the first Nusseiri to pursue higher education. I am incredibly honoured to carry this milestone forward for us all.

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STATEMENT OF CONTRIBUTIONS

I hereby certify that I am the sole author of this work and that no part of this work has been published or submitted for publication. I have used standard referencing practices to acknowledge ideas, research techniques, or other materials that belong to others. Furthermore, I hereby certify that I am the sole source of the creative works and/or inventive knowledge described in this document.

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LIST OF ABBREVIATIONS AND SYMBOLS

AI	Artificial Intelligence
GenAI	Generative Artificial Intelligence
AIO	AI Overviews
PCC	Population Concept Context
AILQ	AI Literacy Questionnaire
PRISMA-ScR	Preferred Reporting Items for Systematic Reviews-Extension for Scoping Reviews
AR/VR	Augmented Reality and Virtual Reality
GPT	Generative Pre-Trained Transformer

Chapter 1. Introduction

1.1 Overview

The rise of Artificial Intelligence (AI) has rapidly reshaped industries, economies, and education, establishing itself as a key technology in modern society. AI is a branch of computer science focused on developing intelligent systems capable of performing tasks that typically require human intelligence (Slimi, 2023). AI has become an integral part of everyday life, powering smartphone features like cameras, personalizing information searches, and generating predictive text suggestions, often without users realizing it (Borasi, 2024). The pervasiveness of AI exemplifies a postdigital world in which digital technologies are no longer perceived as novel or disruptive but as commonplace (Mueller et al., 2021). An emerging subset of AI, Generative Artificial Intelligence (GenAI), has gained significant attention in mainstream domains. GenAI can produce text, images, music, and code by analyzing patterns from vast datasets (Mao et al., 2023). GenAI's influence extended to various contexts as the increased adoption of GenAI tools, such as ChatGPT and Gemini, became embedded in online interactions and digital spaces. For instance, Google has integrated Gemini into search results with a feature called AI Overview (AIO), which provides users with AI-generated summaries to their inquiries. AIO is predicted to reshape users' information-seeking behaviour, contributing to the rise of zero-click queries, in which users accept the generated AI summary without visiting external websites to validate the responses (Williams, 2024). In October 2024, Apple launched its version of AI, 'Apple Intelligence,' in collaboration with OpenAI (Eddy, 2024). Apple users have ChatGPT integrated into their devices, enabling features such as proofreading, text rewriting, and tone adjustments (Eddy, 2024). Similarly, Microsoft released Copilot, an AI-powered tool embedded across its suite of applications, designed to enhance worker productivity by generating, summarizing, and refining content (Powers & Patrizo, 2024). These developments shed light on the growing presence of AI, further shaping how we interact with digital technologies in everyday life. AI's prevalent nature urges individuals, especially students, to engage with these tools through the lens of digital literacy and critical engagement to ensure they preserve human judgment.

A recent survey found that one in five Canadian post-secondary students regularly use GenAI, and frequent users are more likely to support its inclusion in education (Yang & Stadnicki, 2024). AI's growing presence in education has led to discussions about its implications, particularly as students and educators grapple with its benefits and challenges. It is clear that AI is here to stay (Kurtz et al., 2024) and will likely remain a foundational educational technology in the foreseeable future (Zawacki-Richter et al., 2019). A recent report by McKinsey & Company (2023) projects that AI will automate and alter the nature of jobs, creating new roles that demand AI-related competencies. To keep pace with this shift, academic institutions must equip students with the knowledge and skills needed to navigate an AI-driven workforce (Nyale et al., 2024). Thus, to be prepared for workforce demands, students must develop the knowledge and competencies required to use, evaluate, and collaborate effectively with AI technologies. Despite the necessity of cultivating AI literacy, many Canadian institutions have yet to develop comprehensive policies and guidelines that either allow or restrict the use of AI for teaching and learning purposes (Rasky, 2024). Some educators express skepticism about AI's value in education, voicing concerns about students' academic misconduct, diminished higher-order thinking skills, and increased dependence on GenAI technologies (Bates et al., 2020; Chan & Tsi, 2024). Additionally, fears that students will rely on AI to bypass their learning on coursework have led to discussions on redesigning assessments to minimize AI misuse (Borasi, 2024). For instance, Hodges and Kirschner (2023) suggest implementing assignments that require students to reflect on their personal experiences or opinions to reduce the feasibility of GenAI being solely relied upon in the learning process. However, restricting or banning the use of AI in education may fail to address the more significant issue of guiding students to use AI responsibly, as AI is an inescapable reality in the digital era (Anders, 2023). Furthermore, as GenAI becomes more ubiquitous and sophisticated, differentiation between human and AI output grow more complex, requiring proactive AI literacy education rather than restrictive measures (Hodges & Kirschner, 2023). In response, higher education institutions must rethink the purpose of education and adapt their curriculum, pedagogy, and assessment to emphasize higher-order thinking skills (Bennett & Abusalem, 2024). However, research on AI literacy education is in its infancy, necessitating a scoping review to map emerging promising pedagogical practices for developing students' AI literacy in post-secondary education.

1.1.1 AI Literacy

There is no single, universally accepted definition of AI literacy, as its meaning varies based on context, discipline, and purpose. Researchers have made significant progress in conceptualizing AI literacy, yet their definitions emphasize different aspects, from technical skills to ethical considerations and societal engagement. Long and Magerko (2020) provide one of the most widely cited definitions, describing AI literacy as "a set of competencies that enables individuals to critically evaluate AI technologies;

communicate and collaborate effectively with AI; and use AI as a tool online, at home, and in the workplace" (p. 598). AI literacy is positioned as a multifaceted skill set that encompasses meaningful interaction with AI across various domains, requiring both technical proficiency and critical awareness. Other scholars have a different approach to defining AI literacy, emphasizing the ethical dimension. Ng et al. (2021a), for example, expand the definition to include the critical aspect of AI ethics, underlining its relevance to AI's social and human-centered implications. AI ethics should be viewed as a central component of AI literacy, as concerns regarding biases and privacy are crucial in a society increasingly influenced by AI technologies. Hervieux and Wheatley (2024) offer a more reflective perspective, describing AI literacy as a conscious decision to engage in AI discourse and seek knowledge about AI technologies in everyday life. Their depiction suggests that AI literacy is not only about technical skills but also about cultivating a deeper understanding of the role AI plays in our daily experiences. Rasky (2024) approaches AI literacy with a specific focus on GenAI, defining AI literacy as the ability to understand and navigate GenAI tools. These varied perspectives demonstrate that AI literacy is a broad and evolving concept encompassing technical knowledge, ethical awareness, and critical engagement with AI. Scholars continue to refine its definition, reflecting the growing importance of AI across different fields. As discussions progress, understanding AI literacy in a way that accommodates diverse disciplines and applications will be essential for education and workforce readiness (Southworth et al., 2023).

1.1.2 Rationale

While AI literacy is widely acknowledged as a critical competency (Ng et al., 2021b), its practical implementation in higher education remains underexplored. With AI revolutionizing industries, developing AI literacy is necessary for all students, regardless of their field of study. Institutions must prepare students not just to use AI but to evaluate, create, and collaboratively engage with AI technologies (UNESCO, 2024). AI literacy equips individuals with the ability to make informed decisions about AI adoption, advocate for ethical AI practices, and actively contribute to shaping AI's role in society (Dadhich & Bhaumik, 2023). Effective pedagogical strategies are essential to becoming AI literate, ensuring students acquire the knowledge and skills to engage with AI critically and responsibly (Dadhich & Bhaumik, 2023). There is widespread agreement on providing basic AI literacy to every digital citizen, yet effectively implementing it remains a complex challenge (Borasi, 2024). Existing research often focuses on AI's role in personalized learning, automation, and assessment rather than exploring how AI literacy is developed at the post-secondary level (Bennett & Abusalem, 2024). Additionally, research in K-12 education has demonstrated progress in supporting young learners' development of AI literacy. For example, a systematic review by Liu and Zhong (2024) explored how educators teach AI literacy in K-12 environments, revealing promising pedagogical strategies for younger learners. Similarly, Ng et al. (2023a) found that collaborative, project-based, and game-based learning are among the most effective pedagogical approaches in teaching AI literacy to K-12 learners. However, post-secondary institutions lag behind in adopting AI literacy curricula (O'Dea & O'Dea, 2023), leaving a gap in understanding the promising practices associated with teaching undergraduate, graduate, and postgraduate students AI literacy skills (Laupichler et al., 2022a). The scarcity of research related to AI literacy interventions in higher education reflects the need for more detailed investigations into relevant teaching and learning practices in these contexts. Furthermore, although numerous frameworks conceptualize AI literacy as the ability to understand, use, and critically evaluate AI tools, there remains a lack of research in post-secondary settings that examine the most effective pedagogical strategies for building these skills (Nyale et al., 2024).

1.1.3 Objectives

The OECD (2025) emphasizes that integrating AI literacy is a collective responsibility across the broader education system rather than the duty of an individual instructor. To support educators and learners in this effort, the OECD (2025) developed the AILit Framework, which is structured around four domains. These domains include engaging with AI, creating with AI, managing AI, and designing AI, with ethical principles embedded throughout its guidance on the knowledge, skills, and abilities needed to navigate AI-driven contexts (OECD, 2025). As GenAI continues to enhance learning, automate tasks, and reshape traditional educational practices, institutions must balance its benefits with the risks associated with misuse, misinformation, and ethical concerns (Bennett & Abusalem, 2024). Without adequate support, learners may develop habits that compromise academic integrity, neglect essential skills, and overlook opportunities to use AI to enrich their learning and develop new competencies (OECD, 2025). Students and faculty recognize AI's potential to enhance higher education by personalizing instruction, improving accessibility, and supporting student outcomes (Al-Zahrani & Alasmari, 2024). Despite the opportunities of AI, there are substantial concerns about its ethical implications, especially regarding privacy, security, biases in data, and reduced human-to-human interaction (Al-Zahrani & Alasmari, 2024; UNESCO, 2023). Since AI systems are trained on large amounts of data, the quality of this data is susceptible to inaccuracies (Tang, 2024). There is often a lack of transparency about how AI systems make decisions, as biased data can lead to biased outputs, complicating the use and trust in these systems (Tang, 2024). The limitations associated with AI technologies highlight the importance of developing AI literacy that enables students to understand and navigate the associated risks and challenges. However, higher education institutions lack consensus on how AI literacy should be taught to non-technical learners, which skills should be included in AI literacy, and how students should be assessed on AI literacy competencies (Dadhich & Bhaumik, 2023; Laupichler et al., 2022a; Nyale et al., 2023). For instance, Laupichler et al. (2022a) note that it has not yet been decided whether programming skills are part of AI literacy, while Long and Magerko (2020) argue that understanding AI does not require learners to know how to program AI. This scoping review addresses these gaps by investigating effective pedagogical practices to support the facilitation of AI literacy interventions in post-secondary contexts and inform future research.

Long and Magerko (2020) suggest that research efforts may involve exploring how AI literacy curricula can be adapted for different disciplines, what competencies should be prioritized, and how AI literacy should be assessed. Developing standardized instruments to assess AI literacy, especially for post-secondary students, is a crucial step to ensure its validity, reliability, and comparability. Furthermore, such instruments may enable researchers to consistently measure AI literacy across diverse contexts and evaluate students' learning to measure the effectiveness of instructional approaches. For instance, Ng et al. (2023b) designed and validated a rigorous AI Literacy Questionnaire (AILQ) consisting of 32 items to measure students' literacy development across four dimensions, including affective, behavioural, cognitive, and ethical learning. Although the AILQ is designed for secondary students (Ng et al., 2023b), this scoping review seeks to explore reliable AI literacy instruments specifically for post-secondary students. By synthesizing existing research, this review will support AI literacy initiatives and aid post-secondary institutions in developing structured AI education. Furthermore, this scoping review seeks to identify which promising practices are commonly applied, which are underexplored, and where more research is needed. In structuring the research question, the Population Concept Context (PCC) framework (Pollock et al., 2023) provided a structured approach to formulating clear objectives for the scoping review and later identifying and analyzing relevant literature. The review focuses on AI literacy education (concept) for students (population) in post-secondary institutions (context), with an emphasis on promising teaching and learning practices that develop AI-related skills. Therefore, this scoping review is guided by the following research question: What promising teaching and learning strategies are currently used in post-secondary education to develop students' AI literacy skills, and what are their implications on student learning?

1.2 The Role of AI in Student Learning

As the broader implications of AI on education and society continue to shift, AI's impact on student learning cannot be overlooked. Studies report that students in higher education appreciate AI's utility in providing research and writing assistance as well as general guidance on academic-related tasks (Darwin et al., 2023; Farhi et al., 2023).

Despite the affordances of AI in education, there is speculation about its influence on cognitive engagement. The phenomenon of cognitive offloading is of particular concern, in which students rely on external sources, such as AI, to reduce their cognitive load instead of engaging deeply with content (Gerlich, 2025). If students outsource their work to AI, they may not reach a nuanced understanding of the subject matter. The overreliance on AI tools, such as ChatGPT, leads to a superficial understanding of the content, as students prioritize quick outputs over meaningful learning experiences (Bhuman & Ciyan, 2024; Sarwanti et al., 2024). Further, research shows that students' dependence on AI tools can hinder their critical thinking skills, as they may blindly trust AI-generated information without questioning its accuracy or biases (Bhuman & Ciyan, 2024). Consequently, students' creativity, writing skills, and independent thought may be impeded, and the value of critical thinking may be diminished (Farhi et al., 2023). As AI systems grow more sophisticated, critical thinking and independent problem-solving become even more essential (Gerlich, 2025). More importantly, the capabilities of AI to simulate aspects of human intelligence prompt a reevaluation of what it means to be intelligent in a society influenced by these technologies (Korteling et al., 2021). In spite of the identification of AI as a valuable educational resource, it cannot serve as a substitute for human judgment and intuition.

To mitigate the risks of AI on students' cognitive growth, students must work alongside AI technologies to promote the development of higher-order thinking skills. AI tools should be integrated to support inquiry, debate, and critical evaluation rather than to encourage rote learning or passive engagement (Darwin et al., 2023). Lodge et al. (2023) offer guidance on how assessment in higher education can leverage the opportunities of

GenAI while addressing its risks. They emphasize that assessments should prepare students to engage ethically and actively with AI, facilitate meaningful collaboration with peers and AI technologies, and apply AI strategically to maximize learning and evaluation. Moreover, Lodge et al. (2023) offer an example of integrating GenAI in the learning process, which involves permitting a group of students to use GenAI to assist with drafting a written assignment, while documenting the prompts used, the ideas generated, and how the group collaboratively refined AI's contributions. Similarly, Georgopoulou et al. (2024) emphasize that to maximize the benefits of AI, students should be critically engaged with its outputs by understanding how and why AI generates information. Institutions may consider incorporating AI tools into the educational experience to achieve a balanced approach that facilitates meaningful learning and collaborative interaction. For instance, students could evaluate AI-generated content for accuracy, bias, and limitations, ensuring that AI is used as a tool for exploration rather than a replacement for learning (Georgopoulou et al., 2024). Furthermore, an in-depth exploration of AI's capabilities should support students in collaborating with peers in problem-solving tasks to avoid isolating students (Bae & Bozkurt, 2024). In this context, AI literacy may be pivotal in guiding students to collaborate with AI to nurture the development of higher-order thinking skills.

1.3 Scope of AI Literacy Education

Higher education institutions are responsible for equipping students with AI literacy as AI technologies will continue to reshape industries and academic disciplines (Rasky, 2024). Incorporating AI literacy into curricula is not merely about keeping up with technological advancements; it is a strategic necessity for preparing students for the future driven by AI technologies (Kurtz et al., 2024). The scope of AI literacy education must extend beyond technical skills. As Kurtz et al. (2024) further emphasize, fostering creativity, critical reasoning, and ethical awareness is crucial to ensure that students can adapt to emerging AI technologies rather than be displaced by them. A strong foundation in digital literacy is seen as essential for developing AI literacy, as students should understand how computers process information, how algorithms function, and how data is generated to engage with AI technologies critically (Long & Magerko, 2020). Without these skills, students may struggle to comprehend how AI systems operate or evaluate their outputs effectively (Long & Magerko, 2020).

Despite AI's growing role in education, several barriers hinder its integration into higher education curricula. These barriers include financial constraints, lack of infrastructure, limited awareness of AI technologies, and faculty members' lack of confidence and knowledge in using AI in their teaching (O'Dea & O'Dea, 2023). Additionally, the absence of standardized AI literacy curricula and assessment methods has led to fragmented approaches across institutions (Zawacki-Richter et al., 2019). Without proper regulation and guidelines to govern the utilization of AI in post-secondary contexts, it remains unclear how to approach teaching and learning practices related to AI literacy skills development. Although some institutions have implemented some form of AI literacy training, these interventions often lack context-specific approaches tailored to varying academic disciplines (UNESCO, 2024). Expanding access to AI literacy education is particularly crucial for students from non-technical backgrounds. Laupichler et al. (2022a) argue that students from non-STEM disciplines need structured opportunities to engage with AI in ways that align with their field of study. For instance, Teng et al. (2022) found that healthcare students expressed a lack of preparedness about using AI and emphasized the necessity of acquiring foundational AI knowledge through their curricula. Students may struggle to navigate AI technologies in their future careers without opportunities to engage meaningfully with AI while pursuing higher education.

Chapter 2. Methods

2.1 Protocol

A scoping review is a type of knowledge synthesis that is conducted to map existing literature on a topic, identify gaps in the research, and summarize research findings on a particular topic (Arksey & O'Malley, 2005). Therefore, the purpose of this scoping review is to explore and summarize existing literature related to developing students' AI literacy skills in post-secondary education. The 22 items of the Preferred Reporting Items for Systematic Reviews-Extension for Scoping Reviews (PRISMA-ScR) were followed to ensure the scoping review met the requirements. Although a protocol registration is recommended to ensure transparency and methodological rigour (Tricco et al., 2018), it was not pursued due to tight project deadlines and time constraints. Despite not registering a protocol, the review process followed outlined procedures to adhere to the typical undertaking of a scoping review (See Table 2.1).

Table 2.1

Procedure for Conducting Scoping Review

Step	Procedure
1	Enter the search string in Education Source via. EBSCO, ERIC via EBSCO, and Web of Science
2	Filter results by year (2019-2024) and by English (language) whenever applicable
3	Screen titles and abstracts to identify relevant sources of information
4	Download records of applicable sources based on inclusion and exclusion criteria
5	Identify duplicate sources of information and remove them
6	Review the full text of each source and decide if relevant or not
7	Extract and chart data based on key information
8	Summarize results and conduct a thematic analysis of the findings
9	Identify gaps in the eligible sources of evidence

2.2 Eligibility Criteria

Prior to searching relevant databases for literature, the eligibility criteria were drafted based on the PCC framework (See Table 2.2). The population for this review includes adult learners across all fields of study enrolled in any study level at a post-secondary institution, including undergraduate, graduate, or postgraduate students. Students were selected as the population of interest to discover how adult learners respond to certain teaching and learning practices that affect students' cultivation of AI literacy skills. Initially, pre-service teachers were considered within the student population but were later excluded from the eligibility criteria due to differences in learning objectives. Pre-service teachers typically receive AI literacy training with the specific goal of teaching AI in K-12 settings and for their own professional development. However, this scoping review focuses on student-centered AI literacy development in higher education. In addition, faculty and instructor perspectives from higher education institutions were excluded, as this review aims to examine AI literacy from the perspective of students. In terms of the concept, literature that explored AI literacy or digital literacy in relation to AI was considered. This is because digital literacy is seen as a prerequisite for developing AI literacy (Long & Magerko, 2020). Finally, the context of post-secondary education was defined as colleges, universities, or any academic institution providing formal adult education.

Regarding the type of literature, empirical studies employing any research method (e.g., quantitative, qualitative, mixed-methods) and grey literature, including dissertations, theses, conference proceedings, and government reports, were considered. Magazine articles and blogs were excluded as they were considered non-scientific media and may not contribute to the scholarly discourse on AI literacy education. Commentary and opinion articles, as well as literature proposing conceptual or theoretical frameworks, were excluded since these sources may not describe how AI literacy is taught in practice or provide specific pedagogical guidance. In addition, the aim of the scoping review is to explore practical applications of teaching and learning practices as opposed to theoretical recommendations. Other eligibility criteria included literature strictly published in English, as translating texts from other languages may fail to capture nuances in meaning or context-specific terminology. The timeframe for inclusion was set between 2019 and 2024, as literature published in 2025 was not yet available at the time of database searches. Although AI research predates 2019, interest in AI literacy has significantly increased in 2021 and 2022, reflecting a growing focus on AI education (Laupichler et al., 2022a). Furthermore, reviewing the literature based on a five-year timeline seeks to summarize the recency of available sources.

Table 2.2
Inclusion and Exclusion Criteria

	Inclusion	Exclusion
Population	Adult learners in any academic discipline and level of study (i.e., graduate, undergraduate, postgraduate)	Pre-service teachers, instructors and/or faculty members at a higher education institution, librarians, young students (e.g., K-12 learners)
Concept	Discusses a teaching and learning approach to developing AI literacy	Missing focus on AI literacy. The term "AI literacy" is mentioned, but has a different focus.
Context	Written for post-secondary institutions (e.g., college, university)	Written for K-12 environments, librarians, or administrative staff
Type of Source	Empirical studies, grey literature, including dissertations, theses, conference proceedings, government reports, book chapters	Commentary and/or opinion articles, magazine articles, blogs, theoretical or conceptual frameworks
Other	Published within the years 2019-2024 Written in English	Published prior to 2019 or in 2025 Written in a language other than English

2.2.1 Search & Selection of Sources of Evidence

During the beginning stage of the search strategy, multiple search strings were collaboratively developed with a subject librarian at Ontario Tech University (See Appendix). Each search string was then tested in databases that were suggested by the librarian to identify potentially relevant sources of evidence, including Education Source via EBSCO and ERIC via EBSCO. Web of Science was selected as an additional database to perform the search to identify sources of grey literature. The initial search string, which was performed on January 15, 2025, included keywords specific to the instructional design aspect of AI literacy, which included key terms such as "instructional practices" OR "course development" in addition to related keywords for "AI literacy" and "post-secondary" education. During the screening for titles and abstracts, 40 articles met the inclusion criteria. Unfortunately, when screening the full text of the articles to assess for eligibility, only six sources of evidence passed the screening, thereby abandoning the initial search string. This led to the use of a broader search string. Thus, on January 23, 2025, the final search string that was performed in the three databases previously mentioned was: ("artificial intelligence" OR "machine learning") AND ("digital literacy" OR "literacy" OR "AI literacy") AND ("framework" OR "practices" OR "course" OR "curriculum") AND ("university" OR "college" OR "higher education" OR "post secondary" OR "postsecondary").

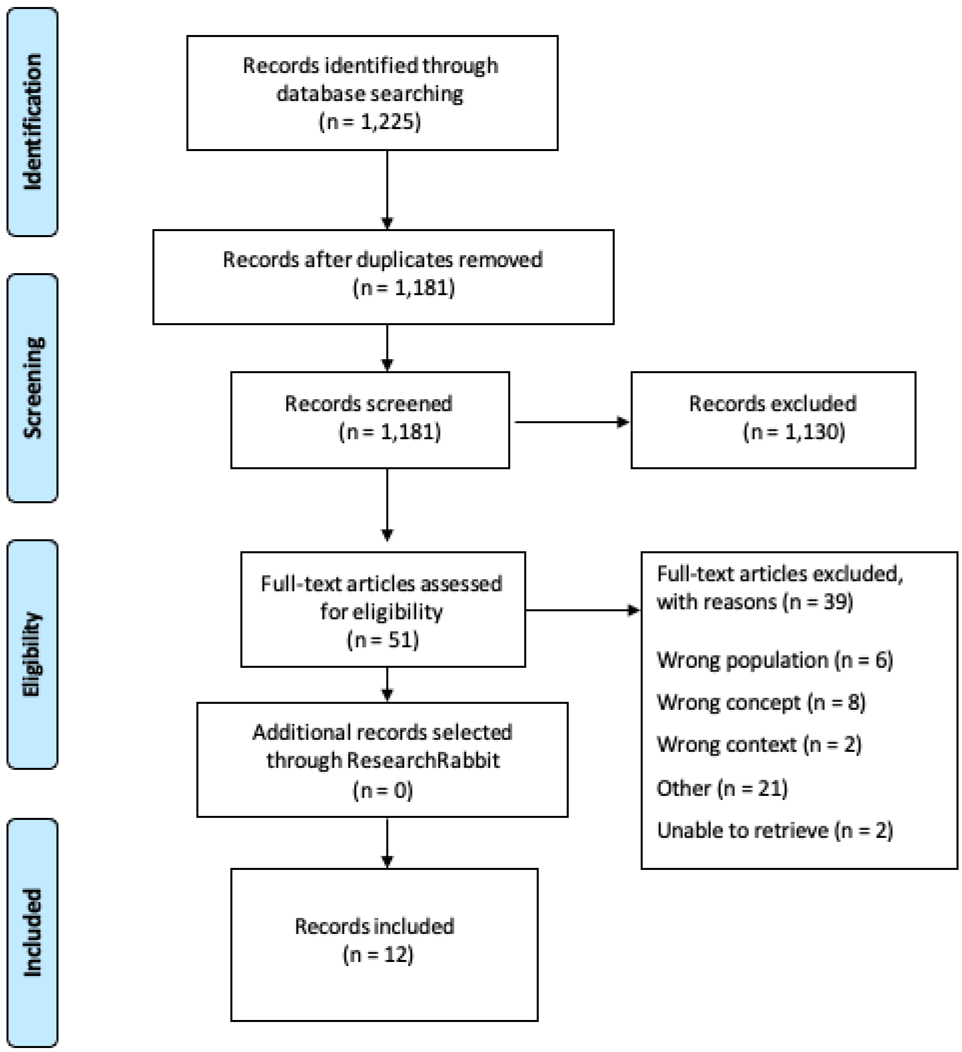
When reviewing the sources of evidence in each database, the results were immediately limited to the five-year publication time frame from 2019 to 2024 and restricted to articles written in English. The search results from the databases were as follows: Education Source via EBSCO (n = 298), ERIC via EBSCO (n = 158), and Web of Science (n = 769), yielding a total of 1,225 records. After removing duplicates, 1,181 articles remained for screening of titles and abstracts. Of these, 1,130 articles were excluded after the eligibility criteria were applied, leaving 51 articles for full-text screening. During the full-text screening, 39 articles were excluded for the following reasons: the population did not meet the specific criteria (n = 6), the articles were not related to AI literacy (n = 8), they were not written for a post-secondary context (n = 2), they proposed a theoretical framework or were opinion/commentary articles (n = 21), or they could not be retrieved (n = 2). As a result, a total of 12 sources of evidence remained from the database search and full-text screening.

2.2.2 ResearchRabbit

To identify additional records, ResearchRabbit, an AI-powered tool for discovering scholarly publications (Cole & Boutet, 2023), was leveraged to complement the database search. The 12 eligible sources of evidence were imported from Zotero into ResearchRabbit, in which ResearchRabbit's algorithm generated 764 recommended publications related to the content of the included sources. To ensure alignment with this scoping review's eligibility criteria, filters were applied to restrict the results to literature published between 2019 and 2024. The recommended publications were then carefully assessed to determine their relevance to the aims of this scoping review. Upon reviewing the titles and abstracts of the publications, none met the eligibility criteria. The majority of recommended publications focused on K-12 education, covering primary, middle, and high school students. Others concentrated on teacher education, educator perspectives, or general discourse of AI in education rather than addressing promising teaching and learning approaches for AI literacy in post-secondary education. Despite the large volume of recommendations, these sources did not align with this scoping review's specific focus. Ultimately, 12 sources of evidence were selected to be included in the scoping review (see Figure 2.1).

Figure 2.1

PRISMA Flow Diagram



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *Preferred Reporting Items for Systematic Reviews and Meta-Analyses*: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097
Modified: The Joanna Briggs Institute Reviewers' Manual 2015. Methodology for JBI Scoping Reviews. Published by the Joanna Briggs Institute, 2015.
For more information, visit: www.prisma-statement.org.
http://joannabriggs.org/assets/docs/sumari/Reviewers-Manual_Methodology-for-JBI-Scoping-Reviews_2015_v2.pdf

2.3 Data Charting Process

To facilitate the data charting process, a spreadsheet was created using Google Sheets to extract and organize relevant data from the included sources of evidence. The data charting process was completed manually. Data were extracted based on key variables, including the author(s), year of publication, geographic location in which the study took place, study population and sample size (where applicable), methodology/methods, teaching and learning practice used, and key findings as they related to the research question. Each source's author(s), year, and geographic location were recorded to keep track of the source's origin and timeline. The study population and sample size were noted, where applicable, to assess the scope and field of study of the participants. Methodology and methods were extracted to determine the research design and techniques employed in each study, whether qualitative, quantitative, or mixed methods. The pedagogical practices, including the content covered and the tools leveraged to support the learning process, were extracted to explore the specific approaches used to develop students' AI literacy within post-secondary education contexts. Key findings were summarized to provide insights into how each article contributed to the understanding of AI literacy in post-secondary education, with a focus on pedagogical approaches. A critical appraisal of the individual sources of evidence was not performed, as this step is not typically required in a scoping review (Tricco et al., 2018). The aim was to map and summarize existing literature rather than assess the quality of the studies included. Following the extraction of relevant data, the findings were synthesized using a thematic analysis approach. This method involved grouping the extracted data into key themes that emerged across the sources. The thematic analysis was used to identify common trends, insights, and discrepancies in the literature, offering a comprehensive overview of the existing research on teaching and learning strategies for AI literacy development.

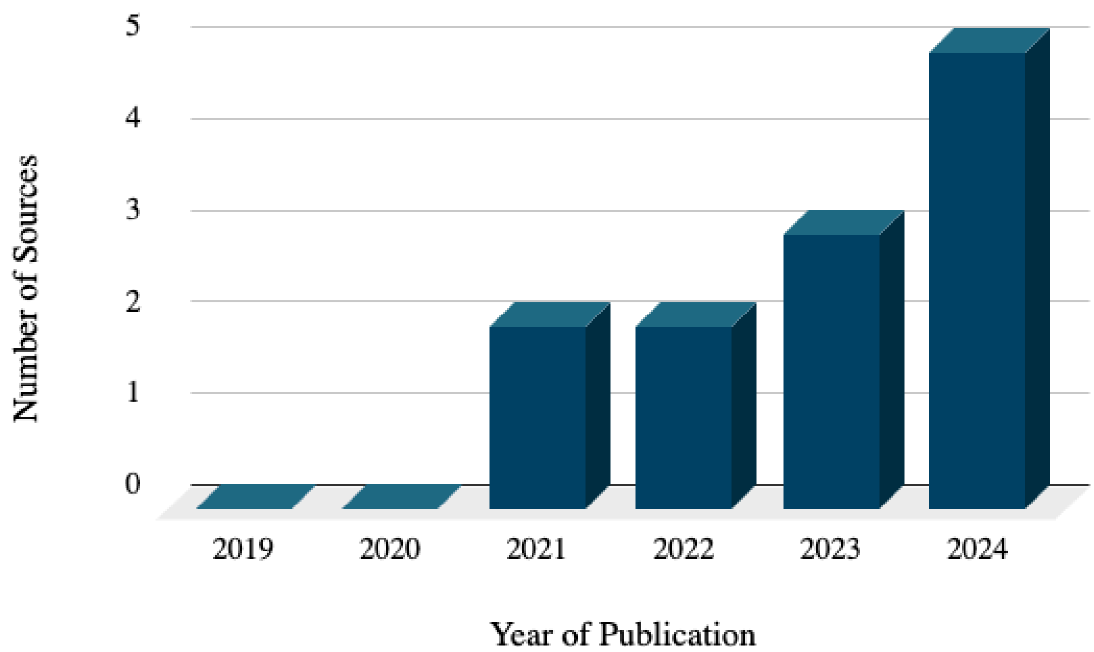
Chapter 3. Results

3.1 Characteristics of Individual Sources of Evidence

The 12 sources of evidence included in this scoping review consisted of journal articles (n = 9) (Chen & Zhang, 2024; Lin et al., 2021; Kong et al., 2021, 2022, 2023; Laupichler et al., 2022; Hu et al., 2023; Naamati-Schneider, 2024; Tzirides et al., 2024), conference papers (n = 2) (Kim et al., 2023; Liao et al., 2024), and a conference proceeding (n = 1) (Strubberg et al., 2024). The studies utilized a range of research methodologies, including mixed-methods (n = 6), quantitative (n = 4), and qualitative (n = 1). Notably, only one study relied exclusively on a qualitative design, which highlights the dominance of quantitative and mixed-methods approaches in the literature. To evaluate the effectiveness of the AI literacy programs, the sources of evidence included quantitative instruments, such as pre-test and post-test surveys and questionnaires, while qualitative methods involved semi-structured interviews and focus groups. The remaining source, Strubberg et al. (2024), did not specify the methodology. In terms of publication year (See Figure 3.1), most were published in 2024 (n = 5), followed by 2023 (n = 3), and an equal amount from both 2022 (n = 2) and 2021 (n = 2). There appears to be a steady growth in the number of sources of evidence related to teaching and learning practices for AI literacy development in post-secondary students. No eligible sources were identified prior to 2021, suggesting that earlier literature on AI literacy may have focused on theoretical perspectives or framework development.

Figure 3.1

Number of Sources by Publication Year



The sources of evidence varied in terms of study participants, though all participants were enrolled in a post-secondary education program and had received little to no prior education with AI. Six sources involved students from diverse academic disciplines (Kong et al., 2021, 2022, 2023; Lin et al., 2021; Strubberg et al., 2024; Tzirides et al., 2024), while three focused specifically on students in healthcare programs, such as radiology and health management (Hu et al., 2023; Laupichler et al., 2022b; Naamati-Schneider, 2024). One article, Kim et al. (2023), combined students from both non-computer science and computer science majors who expressed difficulties learning about AI. The remaining sources of evidence did not specify the participants' fields of study (Chen & Zhang, 2024; Liao et al., 2024). The geographic location of the sources of evidence (See Figure 3.2) spanned various regions around the globe, including Asia (n = 7), followed by North America (n = 3), the Middle East (n = 1) and Europe (n = 1). The concentration of sources in Asia suggests that countries such as Canada and the United

States may be lagging in the development and implementation of AI literacy curricula. A summary of the characteristics of the individual sources of evidence is presented in Table 3.1. The following sections outline the charted findings in alignment with the research question and the objectives of this scoping review.

Figure 3.2

Number of Sources by Country of Origin/Region

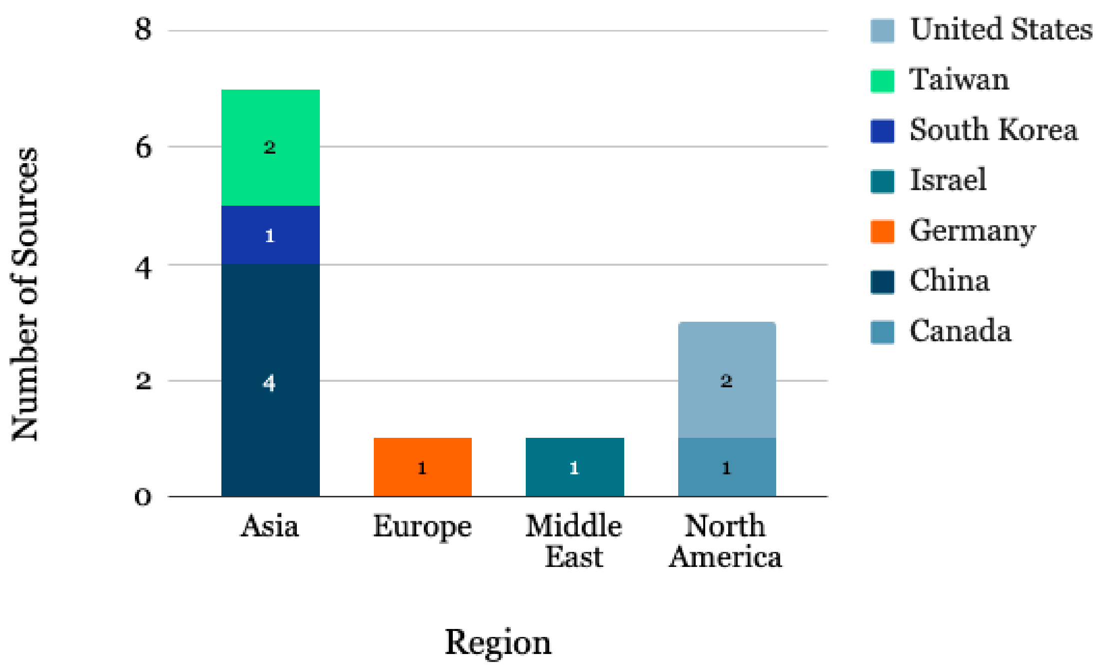


Table 3.1

Characteristics of Sources of Evidence

Authors & Year	Article Type	Country of Origin/Geographic Location	Study Population & Sample Size	Methodology/Methods
Chen & Zhang (2024)	Journal Article	China	University students in their second semester with no prior AI training. Academic discipline not specified. n = 125	Mixed-methods (Quantitative: pre-test and post-test survey; Qualitative: semi-structured interviews)
Hu et al. (2023)	Journal Article	Canada	Diagnostic radiology residents participated in this study. n = 11	Quantitative (pre- and post-workshop surveys)
Kim et al. (2023)	Conference Paper	South Korea	Students enrolled in an AI education course designed for young job seekers pursuing AI-related careers. Students from both non-computer science and computer science majors participated in the study. n = 80 (n = 40 [control group]; n = 40 [experimental group])	Mixed-methods (Quantitative: survey, Qualitative: focus group interview)
Kong et al. (2021)	Journal Article	China	University students from diverse backgrounds (e.g., mathematics, health education, STEM, psychology, etc.) were enrolled in three AI literacy courses. Majority of the students were pursuing bachelor's degrees and included all years of study (i.e., years 1-4). The remaining participated were pursuing postgraduate or higher diplomas. n = 120	Mixed-methods (Quantitative: pre- and post-surveys & tests, Qualitative: focus group interviews)

Authors & Year	Article Type	Country of Origin/Geographic Location	Study Population & Sample Size	Methodology/Methods
Kong et al. (2022)	Journal Article	China	University students from diverse backgrounds (e.g., mathematics, health education, STEM, psychology, etc.) were enrolled in three AI literacy courses. Majority of the students were pursuing bachelor's degrees and included all years of study (i.e., years 1-4). The remaining participated were pursuing postgraduate or higher diplomas. Course 1 (n = 120); Course 2 (n = 82); Course 3 (n = 36)	Mixed-methods (Quantitative: pre- and post-surveys & tests, Qualitative: reflective writings & focus group interview)
Kong et al. (2023)	Journal Article	China	University students from diverse backgrounds (e.g., mathematics, health education, STEM, psychology, etc.) were enrolled in three AI literacy courses. Majority of the students were pursuing bachelor's degrees and included all years of study (i.e., years 1-4). The remaining participated were pursuing postgraduate or higher diplomas. n = 36	Mixed-methods (Quantitative: pre- and post-survey & tets, Qualitative: reflective writings & focus group interview)
Laupichler et al. (2022)	Journal Article	Germany	Medical students in radiology and ophthalmology who were in their third semester or higher participated in the study. n = 24	Quantitative (questionnaire)
Liao et al. (2024)	Conference Paper	Taiwan	University students. Academic discipline and year of study not specified. n = 60 (n = 30 [control group]; n = 30 [experimental group])	Quantitative (pre-test and post-test questionnaire survey)

Authors & Year	Article Type	Country of Origin/Geographic Location	Study Population & Sample Size	Methodology/Methods
Lin et al. (2021)	Journal Article	Taiwan	First-year university students from various academic disciplines (e.g., accounting, business management, architecture, etc.) n = 328	Quantitative (pre-test and post-test surveys)
Naamati-Schneider (2024)	Journal Article	Israel	Third-year undergraduate students enrolled in a healthcare management program participated in this study. n = 65	Qualitative (analysis of reflective journals kept by students)
Strubberg et al. (2024)	Conference Proceeding	United States	College students from various disciplines, such as criminal justice, business, English, and neuroscience. The sample size is unspecified.	N/A
Tzirides et al. (2024)	Journal Article	United States	University students pursuing graduate degrees (i.e., certificates, masters, and doctoral degrees). Students were from diverse academic backgrounds, with the majority specializing in Education and Humanities. Year of study not specified. n = 37	Mixed-methods (Quantitative: pre- and post-course surveys, Qualitative: semi-structured interviews)

3.1.1 Assessment of AI Literacy

In meeting one of the objectives of this scoping review, the following section provides a detailed description of the instruments and tools used to evaluate post-secondary students' gains in AI literacy (See Table 3.2). As mentioned in the previous section, the sources of evidence included in this review utilized a range of quantitative, qualitative, and mixed-methods approaches to assess AI literacy development. The majority of the studies (n = 8) relied on pre- and post-test designs and were triangulated with qualitative measures to provide a more comprehensive interpretation of students' conceptual understanding, perceived confidence, or self-reported AI literacy (e.g., Chen & Zhang, 2024; Hu et al., 2023; Liao et al., 2024; Lin et al., 2021). Common instruments included five-point Likert-scale surveys and questionnaires that measured students' familiarity with AI concepts, ethical awareness, and confidence in using AI technologies (e.g., Kong et al., 2023; Laupichler et al., 2022b; Tzirides et al., 2024). Two sources of evidence leveraged validated or adapted instruments, such as the Medical Artificial Intelligence Readiness Scale for Medical Students (MAIRS-MS) (Laupichler et al., 2022b) and the AI Literacy Scale developed by Lin et al. (2020) (Lin et al., 2021). In some cases, instrument reliability was reported (n = 5) (e.g., Chen & Zhang, 2024; Kong et al., 2021; Kong et al., 2022; Kong et al., 2023; Laupichler et al., 2022b). Another common trend used by the authors was to develop instruments by seeking out relevant literature (e.g., Chen & Zhang, 2024; Lin et al., 2021). Regarding the qualitative methods that complemented the quantitative measures, the studies evaluated students' AI literacy by examining data from focus group interviews, semi-structured interviews, and reflective statements made by students. Only one source of evidence relied exclusively on qualitative data derived from students' reflective journals (Naamati-Schneider, 2024). Overall, there appears to be a diverse range of assessment methods aimed at measuring students' AI literacy. However, there is a lack of a universally accepted and validated instrument to assess such competency.

Table 3.2

AI Literacy Assessment Methods

Author(s)	Methodology	Assessment Type / Instruments	Assessment Focus
Chen & Zhang (2024)	Mixed Methods	Pre-/post-tests; AI Concepts Test (reliability = 0.67); AI Literacy Test (reliability = 0.88); AI Empowerment Test (reliability = 0.95); Semi-structured interviews	AI concepts, self-perceived AI literacy, AI empowerment
Hu et al. (2023)	Quantitative	Pre-/post-workshop surveys	Perceived confidence and opinions on using AI in future careers in medicine
Kim et al. (2023)	Mixed Methods	Cognitive skills test (low/high-order); Student satisfaction survey; Focus groups	Learning outcomes from flipped classroom model; satisfaction and perceptions with flipped learning in developing AI literacy
Kong et al. (2023)	Mixed Methods	Pre-/post-tests; AI Concepts Tests(reliability = 0.66, 0.67); AI Literacy Survey (reliability = 0.89); AI Empowerment Survey (reliability = 0.93); Ethics Awareness Survey (reliability = 0.76); Focus groups; Written reflections	AI concepts, self-perceived AI literacy, empowerment, and ethical awareness
Kong et al. (2022)	Mixed Methods	Pre-/post-tests; Flipped Classroom AI Literacy Survey; Focus groups; Reflective statements	Effectiveness of flipped learning; perceived understanding of AI and ethics
Kong et al. (2021)	Mixed Methods	Pre-/post-tests; AI Concepts Test (reliability = 0.66); AI Literacy Survey (reliability = 0.89); AI Empowerment Survey (reliability = 0.93); Focus groups	AI knowledge, perceived AI literacy, AI empowerment, and satisfaction to flipped classroom learning approach
Laupichler et al. (2022b)	Quantitative	MAIRS-MS (Medical Artificial Intelligence Readiness Scale) developed by Karaca et al. (2021) (reliability = 0.88)	Perceived preparedness to use AI in healthcare
Liao et al. (2024)	Quantitative	Pre-/post-test questionnaire surveys	Learning abilities and attitudes prior to and after completing AI literacy program
Lin et al. (2021)	Quantitative	Pre-/post-tests; AI Literacy Scale (adapted from Lin et al., 2020) (reliability = 0.943); AI Understanding Scale (expert-developed); AI Ethics Scale adapted from Jobin et al. (2019) and Hagendorff (2020) (reliability = 0.7)	AI literacy, conceptual understanding, awareness of AI ethics
Naamati-Schneider (2024)	Qualitative	Thematic analysis of reflective journals	AI literacy development and ethical considerations in health management
Strubberg et al. (2024)	N/A	N/A	N/A
Tzirides et al. (2024)	Mixed Methods	Pre-/post-course surveys; Written reflections	Familiarity with AI/Machine Learning concepts, perceived learning outcomes, AI competence

3.1.2 Definitions and Descriptions of AI Literacy

To further contextualize how AI literacy was measured, the following section describes how the sources of evidence conceptualized AI literacy (See Table 3.3). A common pattern emerged across several sources of evidence, which discussed that AI literacy involves understanding basic AI concepts, applying AI-related knowledge to real-world situations, and using AI responsibly and ethically (e.g., Chen & Zhang, 2024; Kong et al., 2021; Lin et al., 2021; Tzirides et al., 2024). Other sources extended this view by incorporating affective and sociocultural dimensions, aiming to empower individuals to confidently engage in an AI-driven world (Chen & Zhang, 2024; Kong et al., 2022; Kong et al., 2023). While Kim et al. (2023) did not define AI literacy directly, they referenced relevant literature that framed it as an essential competency for citizenship and highlighted the importance of understanding AI-related concepts and ethical implications. Naamati-Schneider (2024) noted that using, creating, and evaluating AI requires a level of digital literacy, including data literacy and critical thinking. Two sources of evidence situated AI literacy within a disciplinary need, as seen in medical education, describing AI literacy as the ability to understand how AI applications work and the ability to evaluate its strengths and limitations (Hu et al., 2023; Laupichler et al., 2022b). Few sources of evidence did not formally define AI literacy or make any statements regarding what it entails (Liao et al., 2024; Strubberg et al., 2024).

Table 3.3

Descriptions of AI Literacy

Author(s)	Definition/Description of AI Literacy
Chen & Zhang (2024)	AI literacy involves understanding fundamental AI concepts (e.g., machine learning, natural language processing, neural networks), applying knowledge in real-world contexts, and developing basic programming awareness. It also includes ethical and responsible use (e.g., privacy, transparency, societal impact) and emphasizes empowerment through real-world AI projects and community engagement.
Hu et al. (2023)	Does not provide a definition of AI literacy but highlights that "radiologists are entrusted with integrating medical imaging AI tools with decision-making and therefore require sufficient AI literacy to evaluate its strengths and limitations" (p. 1).
Kim et al. (2023)	Does not define AI literacy directly but references relevant literature. AI literacy is framed as an essential competency for citizenship in a rapidly changing society (Long & Magerko, 2020). Developing AI literacy involves understanding basic AI techniques and concepts, as well as recognizing the ethical and societal impacts of AI (Park & Suh, 2021).
Kong et al. (2021)	Proposes that AI literacy includes three components: understanding AI concepts, applying them for evaluation, and using them to understand and solve real-world problems.
Kong et al. (2022)	Adopts the AI literacy framework developed by Kong and Zhang (2021), which includes cognitive, affective, and sociocultural dimensions, focusing on understanding AI concepts, empowering individuals to respond to AI in daily life, and encouraging ethical AI use.
Kong et al. (2023)	Also uses Kong and Zhang's (2021) framework, comprising cognitive, affective, and sociocultural dimensions, emphasizing knowledge of core AI concepts, confidence to engage in the digital world, and ethical use of AI.
Laupichler et al. (2022b)	Situates AI literacy within a medical context, describing it as the ability to understand how AI applications work and interpret their results. Emphasizes practical comprehension over programming or mathematical skills, particularly for students from non-technical backgrounds.
Liao et al. (2024)	Does not offer a definition or statement on AI literacy.
Lin et al. (2021)	AI literacy includes students' understanding of basic AI concepts and awareness of AI's ethical and societal impacts.
Naamati-Schneider (2024)	Does not define AI literacy but notes that using, creating, and evaluating AI requires students to have certain digital literacy skills, including critical thinking and data literacy.
Strubberg et al. (2024)	Does not offer a definition or statement on AI literacy.
Tziridies et al. (2024)	Defines AI literacy as a multifaceted concept that includes understanding AI technologies, their responsible and effective use, and applying critical thinking to their design and implementation.

3.2 Results of Individual Sources of Evidence

The remaining data were collected to fulfil the remaining objectives and the research question of this scoping review, which aimed to explore: What promising teaching and learning strategies are currently used in post-secondary education to develop students' AI literacy, and what are their implications on student learning? Key findings of each source of evidence were charted, coded, and thematically analyzed based on the reported outcomes of the learning approaches used to support AI literacy development. Additional data, including the topics and content covered and the digital tools used, were sought to provide a more comprehensive understanding of each approach. The overall aim was to identify the key features of instructional practices that can inform future efforts to design and implement AI literacy initiatives in post-secondary contexts. Thus, the thematic analysis covered four themes related to teaching and learning approaches, which were flipped classroom learning, experiential and project-based learning, problem-based learning, and collaborative and formal classroom learning.

3.3 Learning Approaches

3.3.1 Flipped Classroom Learning

Some studies (n = 4) adopted a flipped classroom learning approach to support AI literacy development among post-secondary students. Kim et al. (2023) implemented a flipped classroom learning approach in a university-level course focused on the main topic of 'Artificial Intelligence of Things,' which introduced fundamental AI concepts and theories. Although the study did not report on how the flipped classroom approach contributed to the development of students' AI literacy, it evaluated the approach's utility in supporting learners to develop the skills needed to understand AI. The findings revealed that the students demonstrated enhanced academic achievement, including the development of both low- and higher-order thinking skills, compared to those in a lecture-based control group. Both the flipped learning group and the lecture-based group reported similarly high satisfaction with their learning experiences in the AI literacy program. Although the study did not specify the rationale behind the high satisfaction reported by both groups, students with prior experience in a flipped learning model expressed significantly higher satisfaction than those without such experience (Kim et al., 2023). Laupichler et al. (2022b) found similar results in terms of learning satisfaction among medical students participating in an AI literacy course delivered through a flipped learning model. The AI literacy course was adapted for medical students in radiology, which explored topics such as the risks and opportunities of AI in medical imaging. Students gained a stronger understanding of AI and its application in medical settings, including its growing role in the future of medical professions. The observed gains in students' AI literacy were evidenced by the high scores students achieved on the items of MAIRS-MS instrument that assessed their knowledge of AI concepts and awareness of its practical applications. Time constraints limited the inclusion of in-depth discussions about the ethical implications of AI in the medical field, which contributed to students' limited understanding of these critical considerations (Laupichler et al., 2022b). Nonetheless, the findings from Kim et al. (2023) and Laupichler et al. (2022b) indicate that a flipped classroom learning approach could be a useful approach for nurturing AI literacy in students. Both sources of evidence highlighted improvements and preferences in future iterations of AI literacy education in relation to the design of the flipped classroom approach. For instance, students recommended improvements, such as clearer explanations of basic AI terminology and more opportunities for collaborative learning activities (Kim et al., 2023). In contrast, Laupichler et al. (2022b) noted that students preferred self-directed online study materials over in-class active learning sessions. However, the preference for self-directed learning was marginal, as the classroom sessions took place virtually during the pandemic, which might have negatively impacted how students experienced the active learning components during the classroom sessions (Laupichler et al., 2022b).

Other studies have found that the flipped classroom learning approach improved students' understanding of AI concepts and supported inquiry-based learning, enabling them to apply their AI knowledge across academic, professional, and personal contexts (Kong et al., 2021; Kong et al., 2022). The students appreciated how the learning approach addressed time constraints in class, allowing them to explore complex and rapidly evolving AI topics more deeply through independent learning (Kong et al., 2021). Although flipped classroom learning was initially successful, Kong et al. (2022) found that students responded less positively when the flipped learning model was combined with a project-based approach in the third section of a three-part course. In the third section, students indicated that the lack of self-motivation and immediate instructor support and guidance during independent study and in-class activities hindered their learning, particularly when they engaged with unfamiliar content. While the flipped classroom model was effective for learning foundational AI concepts, it was less suitable for covering the ethical implications of AI. These results suggest that the content of AI literacy initiatives may impact how students develop AI literacy as opposed to the instructional approach alone. Students explained that the self-study content on AI ethics was more difficult to navigate because they did not receive opportunities for timely guidance and clarification on this complex topic (Kong et al., 2022). Although Kong et al. (2022) included university students from varying academic years, it was not reported whether year level or age influenced the outcomes of the study.

3.3.2 Experiential & Project-Based Learning

The following set of sources of evidence employed experiential and project-based learning approaches (n = 3). Kong et al. (2023) implemented a project in which students worked in groups to identify real-world problems and create AI-based applications using tools introduced in class. For example, one group of students created a mindfulness chatbot that incorporated ethical safeguards, such as filtering harmful and biased answers and protecting users' personal data. The project work enabled students to apply their foundational knowledge of AI, consider ethical principles, such as autonomy, fairness, transparency, and privacy, and reflect on the broader societal implications of AI technologies. Students described that this hands-on approach deepened their conceptual understanding and ethical awareness of AI, thereby contributing to enhanced AI literacy (Kong et al., 2023). In a study by Tzirides et al. (2024), students composed essays on AI-related topics, such as the implications of AI on student learning, which were evaluated using a custom AI review tool in conjunction with feedback from GenAI and human peer reviewers. Students then used GenAI tools to create visual artefacts to capture their experiences with both review types, supplemented by a written reflection that described their creative process and the GenAI tool used. The practical engagement with GenAI promoted students' interest in applying AI in academic and professional contexts, increased their confidence in using AI, and supported their growth in AI literacy. While students generally valued both AI-generated and peer feedback, some students expressed concerns related to privacy and accuracy, highlighting the need for critical engagement with AI tools (Tzirides et al., 2024). In another study, Liao et al. (2024) combined project-based learning with experiential learning through the use of immersive Augmented Reality and Virtual Reality (AR/VR) technologies. The students were placed in physical and simulated scenarios where they asked questions, applied knowledge, and solved problems related to a series of real-world applications of AI, such as AI in smart homes, unmanned factories, and in various fields like entertainment and medical care. Students who interacted with the AR/VR technology demonstrated improved AI knowledge, more positive learning attitudes about AI, and higher satisfaction with their learning experiences compared to those in a control group without the AR/VR technology (Liao et al., 2024).

3.3.3 Problem-Based Learning

Only one source of evidence utilized a problem-based learning approach towards promoting AI literacy in students. Naamati-Schneider (2024) presented third-year healthcare management students with the task of having discussions with ChatGPT on the topic of hospital accreditation and later organizing their interactions into themes to support reflective learning. Prior to commencing the problem-based approach, students received thorough guidance on how to use ChatGPT, which aimed to build their familiarity and proficiency with the tool. The students were encouraged to develop foundational AI literacy, as evidenced by their reflections from the learning experience. For instance, students recognized that while ChatGPT provided objective data, it required them to critically interpret the data and form their own conclusions. Through this cautious approach, students learned to evaluate ChatGPT's output rather than passively accept the information. However, students struggled to obtain relevant and desired responses due to a lack of prompt engineering skills. To address this challenge, students learned to clarify their prompts with more detail, which led to more accurate responses from ChatGPT. Engaging in repeated questioning and persistent efforts to improve response quality also contributed to the development of students' high-order thinking skills (Naamati-Schneider, 2024).

3.3.4 Collaborative & Formal Classroom Learning

The remaining sources of evidence (n = 4) did not leverage a particular learning approach, such as project-based or problem-based learning, but rather incorporated a variety of methods. These sources reflected formal classroom learning environments supplemented with lectures and interactive components. Chen and Zhang (2024) implemented a course for first- and second-year students that integrated didactic instruction with collaborative practical sessions, including a variety of group-based activities. The course provided students with a general overview of AI systems through theoretical lectures, case studies, and independent tasks. The findings demonstrated improvements in students' AI knowledge and confidence in using AI technologies in daily contexts, while applying a critical lens when discussing the real-world implications and reliability of AI systems (Chen & Zhang, 2024). Lin et al. (2021) utilized a similar course structure that combined lectures with hands-on activities, independent tasks, and group work to deliver an AI literacy program for first-year non-engineering students. One of the independent activities involved students conducting image classification experiments using Microsoft Azure's Custom Vision. Students adjusted the number of images to observe how the dataset size impacted model accuracy. The course significantly enhanced students' understanding of AI concepts and led to more positive attitudes towards AI and its ethical dimensions. While case-based discussions were effective in increasing awareness of AI ethics among low AI-literate students, case studies were less impactful for students who already had strong knowledge of AI ethics. Based on the varying gains of AI ethics, Lin et al. (2021) suggested that students with more awareness of the ethical implications associated with AI may benefit more from critical engagement strategies, such as debates and structured case analyses.

Hu et al. (2023) developed a workshop for radiology residents that utilized lectures, case studies, and programming exercises to support foundational AI training. The students were introduced to basic AI concepts, such as machine learning, during the lecture, which they later applied to relevant programming exercises. For example, one programming activity involved training an AI model to predict malignancy from tumour images. Although it was not specified whether these activities were conducted individually or in groups, approximately half of the students reported gains in AI knowledge. In addition, the students expressed interest in continued AI education to strengthen their understanding of AI applications in medical contexts (Hu et al., 2023). Finally, Strubberg et al. (2024) offered a seminar composed of students from diverse academic disciplines, including business, criminal justice, neuroscience, that alternated between theory- and application-focused assignments tailored to students' respective fields. The theory-based assignments included student-led discussions of AI's impact on the students' particular field of interest, while the application-focused assignments ranged from guided exploration of various GenAI tools and weekly reflection journals. Students reported increased confidence and enthusiasm for using AI tools, particularly when they had autonomy to explore topics that aligned with their personal interests and academic backgrounds. Moreover, the seminar's modules, which examined the use of GenAI in the writing process, supported students' awareness of the ethical implications of AI. In addition, the student-led discussions during the theory-based portions of the seminar encouraged students to refine their ethical views on AI use in academic and professional settings and become more comfortable debating these topics. However, the findings also indicated a need to balance structured activities with opportunities for independent exploration to effectively build AI literacy among students (Strubberg et al., 2024).

3.4 Topics and Content Covered

Across the included sources of evidence, AI literacy was addressed through a range of topics and concepts, which commonly fell into three broad categories: foundational AI concepts, ethics and societal implications of AI, and real-world applications of AI.

All of the sources introduced students to fundamental AI theories and concepts related to AI, such as machine learning, supervised and unsupervised learning, deep learning, and the distinction between strong and weak AI (Hu et al., 2023; Kim et al., 2023; Kong et al., 2021; Kong et al., 2022; Kong et al., 2023; Liao et al., 2024; Tzirides et al., 2024). Few sources also included historical overviews of AI or general frameworks to build students' conceptual understanding (Chen & Zhang, 2024; Lin et al., 2021; Strubberg et al., 2024), and one source provided an overview of effective ChatGPT usage (Naamati-Schneider, 2024). Chen and Zhang (2024) recommend providing scaffolding by gradually introducing AI concepts and reinforcing them with real-world examples across domains. In some sources of evidence, students actively applied AI concepts through targeted exercises aimed at deepening their understanding (Hu et al., 2023; Kong et al., 2021; Kong et al., 2023). For example, after learning about the five principles of machine learning, students took their conceptual knowledge and applied it to practice by building and training models to classify images and testing the models' predictive capabilities (Kong et al., 2021).

The ethical considerations and societal implications of AI were a key focus in multiple studies. AI literacy initiatives explored ethical dilemmas related to AI technology development (Chen & Zhang, 2024; Kong et al., 2022; Kong et al., 2023; Lin et al., 2021), the strengths and limitations of AI in medical settings (Hu et al., 2023), data privacy and algorithmic bias (Tzirides et al., 2024), and responsible use of GenAI in academic and professional settings (Strubberg et al., 2024). In some cases, in-depth discussions about the ethical implications were planned but not delivered due to time constraints (Laupichler et al., 2022b), suggesting that the discussion of AI ethics should be prioritized in initiatives that aim to build AI literacy. Interestingly, Lin et al. (2021) noted that while students' understanding of AI's ethical implications improved, more in-depth discussions around this topic were needed to strengthen their ethical awareness.

Contextualized and real-world applications of AI were common across a handful of the sources of evidence. In medical education, students explored the use of AI in diagnostic processes in radiology, the strengths and limitations of AI in the medical field, as well as the broader implications of AI in future medical practice (Hu et al., 2023; Laupichler et al., 2022b). Liao et al. (2024) introduced students to AI in smart technologies, such as smart homes, factories, and robots, and in other fields like transportation and entertainment to demonstrate how AI can simulate human behaviour. Finally, one source encouraged students to seek relevant literature related to AI in their particular field of study (Strubberg et al., 2024), supporting student agency and autonomy through personalized exploration.

3.5 Digital Tools Used

A variety of digital tools were employed across the reviewed sources of evidence to support students' development of AI literacy. The tools were grouped by their primary pedagogical function, including programming practice and AI model development, ethical reflection, contextual applications, and exploration of GenAI platforms. Several sources of evidence (n = 6) incorporated programming environments and tools to interact with and understand AI models (Hu et al., 2023; Kim et al., 2023; Kong et al., 2021; Kong et al., 2022; Kong et al., 2023; Lin et al., 2021). For example, Hu et al. (2023) utilized Google Colaboratory to allow students to execute AI-related code, while Kong et al. (2021) introduced k-nearest neighbours (KNN) algorithms and decision trees as interactive tools to help students understand how AI and machine learning models classify information. The KNN algorithm is a common machine learning method used for classification tasks, which students applied by mapping data points to determine how a new student would be grouped based on English and mathematics scores (Kong et al., 2021). Kong et al. (2022) and Kong et al. (2023) offered platforms, such as Microsoft Azure Machine Learning Studio, Microsoft Azure QnA Maker, and Google's Teachable Machine to allow students to create their own AI models. Lin et al. (2021) used Custom Vision by Microsoft Azure to support students in building an AI image recognition model, and incorporated a motor-controlled car kit to demonstrate model training through tasks such as recognizing traffic signs.

The following articles (n = 4) used tools to foster students' critical reflection on the ethical implications of AI. Kong et al. (2022) and Kong et al. (2023) used Microsoft Azure Machine Learning Studio and Google's Teachable Machine to offer hands-on experiences that deepened students' awareness of the ethical issues associated with AI model development, such as transparency and non-maleficence. Lin et al. (2021) used Custom Vision and the motor-controlled car kit to illustrate how inadequately trained models may produce adverse outcomes, prompting students to reflect on issues related to data quality and algorithmic bias. In another approach, Naamati-Schneider (2024) incorporated ChatGPT into a problem-based learning assignment, encouraging students to reflect on the limitations of ChatGPT's outputs, particularly regarding the accuracy and reliability of AI-generated information.

In addition to programming examples and ethical reflection, several sources of evidence (n = 3) utilized digital tools to offer contextual applications of AI and provide immersive learning experiences. Hu et al. (2023) engaged students in training decision tree classifier models using Google Colaboratory to predict medical imaging data for radiology residents. Similarly, Laupichler et al. (2022) introduced the Digital Imaging and Communications in Medicine (DICOM) system to allow students to view anonymized medical imaging data to provide a better understanding of AI's role in diagnostic processes. Finally, Liao et al. (2024) integrated AR/VR technologies into their AI literacy program to support experiential and project-based learning related to AI applications in smart homes and other environments.

The last set of sources of evidence (n = 3) focused on developing students' AI literacy through playful exploration and critical evaluation of AI-generated content, particularly using ChatGPT and other GenAI platforms. Strubberg et al. (2024) incorporated ChatGPT and other GenAI platforms to assist in the writing process and encourage experimental exploration of AI's capabilities. Naamati-Schneider (2024) used ChatGPT as the primary tool to facilitate dialoguing exercises aimed at building students' AI literacy. To support understanding, students gained proficiency with the tool through guided instruction and interactive practice. Students then compiled questions to input to ChatGPT to investigate the hospital accreditation dilemma, critically analyzed ChatGPT's responses from multiple stakeholder perspectives, and evaluated and verified the AI-generated content (Naamati-Schneider, 2024). Tzirides et al. (2024) empowered students' development of AI literacy by integrating a custom Generative Pre-Trained Transformer (GPT) in combination with human insight to assist in the peer-review process for student essays. By engaging with the AI review tool, students learned to critically evaluate and interpret AI-generated feedback, which made them more aware of GenAI's limitations, including inaccuracy and potential bias. In addition, GenAI image tools, such as DALL-E, Midjourney, and Stable Diffusion, were offered to help students practice their prompt engineering skills and critically evaluate the effectiveness of AI-generated visuals in representing their learning experiences.

3.6 Synthesis of Results

In addressing this scoping review's question and objectives, the synthesis of results is presented in tabular format. The series of tables (See Table 3.4, 3.5, and 3.6) provide a clear and cohesive overview of each included source of evidence regarding the learning approaches in relation to student outcomes, the topics and content covered, and the digital tools used.

Table 3.4

Charted Data for Learning Approaches

	Collaborative & Formal Classroom Learning	
Author(s)	**Learning Tasks**	**Key Findings**
Chen & Zhang (2024)	Fourteen sessions were conducted over a four-month training period. An equal mix of instructor-led lectures and group-based practical sessions was used to help students apply their knowledge to solve specific tasks. The course leveraged the case method, group exercises, independent practical tasks, and group discussions.	- Improved AI literacy; increased understanding of AI concepts and capability in using AI technologies confidently. - The course encouraged participants to think more critically about AI applications, including their reliability and real-world implications. - Participants developed a greater awareness of AI's real-world applications and reliability, demonstrating a willingness to apply their AI knowledge in everyday contexts
Hu et al. (2023)	A three-week workshop was delivered. Each session consisted of equal parts didactic lecture, case studies in literature and media, and programming demonstrations. In the third week, students were provided with optional self-study materials, including journal articles and annotated software code.	- Half of the participants felt that their AI knowledge somewhat improved, while a smaller fraction of the participants felt their AI knowledge greatly improved. - Participants expressed interest in continuing AI education to deepen their understanding of AI applications in their medical field.
Lin et al. (2021)	A three-week AI course was delivered, consisting of instructor-led lectures, group-based case studies, and training exercises. In the second week, students trained an AI model to perform image classification experiments to observe how dataset size affected model accuracy. In the third week, they applied their knowledge to train an AI model to recognize traffic signs and used the model to operate a motor-controlled car kit.	- Participants' AI literacy improved significantly following the course, particularly through hands-on activities that reinforced their understanding. - Participants demonstrated a more positive attitude toward AI, AI ethics, and collaborating with peers, suggesting that AI literacy education that combines group work with hands-on activities can effectively support learners from non-STEM backgrounds. - Case discussions regarding AI ethics helped increase low AI-literate participants' awareness of AI ethics. Participants' who had high AI literacy demonstrated a higher awareness of AI ethics. - For participants with advanced ethical AI literacy, traditional case-based instruction was less effective. This suggests that these participants could benefit more from interactive and critical engagement strategies, such as structured debates and in-depth case analyses.
Strubberg et al. (2024)	A seminar (duration not specified) was offered, beginning with an introductory module that demonstrated how technologies such as ChatGPT could support student engagement throughout the writing process. Weeks alternated between theory- and application-focused assignments. Theory assignments included discussions on technology history and ethics, readings from popular publications, and paired, student-led discussions of AI in industries selected by students. Application assignments involved foundational lessons on large language models and chatbots, guided play with GenAI platforms, and weekly reflective journals on AI use.	- Participants showed greater confidence and satisfaction when using AI for academic and professional uses and developed more refined ethical stances towards AI use in various settings. - Participants demonstrated greater enthusiasm and produced higher-quality work when given more creative freedom during hands-on lab sessions and when discussion topics aligned with the lab activities. - A tension emerged between participants' preference for structured play and their ability to apply AI skills in professional settings, suggesting both aspects are crucial for developing AI literacy. Combining opportunities for playful exploration and direct application to participants' desired professional contexts is a suitable way for them to develop AI literacy.
	Flipped Classroom Learning	
Author(s)	**Learning Tasks**	**Key Findings**
Kim et al. (2023)	A 30-hour AI literacy program was conducted, combining theoretical and practical sessions. The experimental group (flipped learning) received lecture videos for conceptual learning and participated in Q&A on Padlet as out-of-class activities. In-class sessions included mini-lectures, discussions, hands-on programming training, and project work. The control group had no out-of-class activities but received theory lessons, discussions, and the same hands-on and project work during class time.	- The flipped classroom approach enhanced academic achievement (students took a test that measured their development of both low-order and higher-order thinking skills) for participants, regardless of their major. - Both the experimental (flipped learning) and control (instructor-led) groups reported high overall satisfaction with the AI course, with no significant difference between them. - Participants expressed high satisfaction with the flipped classroom approach, indicating that this method is useful for AI education - Participants suggested that future iterations of the flipped classroom approach should include explaining basic AI terms, additional opportunities for group activities, and encouragining active involvement in and out of the classroom
Kong et al. (2022)	A 30-hour course composed of three parts was delivered using a flipped classroom approach with self-directed learning materials. In the third course, a project-based learning approach was also adopted. During the first part, students applied the five steps of machine learning to conduct image recognition tasks. In the second part, they participated in lab sessions and discussions to learn and apply deep learning. In the final part, students worked in groups to develop AI-based models to solve real-world challenges.	- The flipped classroom approach was effective in developing participants' understanding of AI concepts and supported inquiry-based learning. - Project-based learning improved participants' understanding of AI concepts and ethics, but they found flipped learning more effective in earlier courses and needed more support from the instructor
Kong et al. (2021)	A three-week course was delivered, including self-directed learning materials, discussions, workshops, hands-on activities, and case studies. In the first week, students discussed the application and impact of AI. In the second week, they performed image recognition tasks to understand machine learning. In the third week, students explored supervised and unsupervised learning by applying KNN algorithms to case studies. For example, they used the algorithm to map data points and group a new student based on English and mathematics scores.	- Participants significantly improved their understanding of AI concepts, with the flipped classroom approach proving effective in teaching key AI topics. - Participants reported gains in self-perceived AI literacy and felt more empowered to apply AI knowledge in their studies, careers, and daily lives. - Participants emphasized that AI's complexity and rapid evolution made it challenging to cover all content within limited class time. They found the flipped classroom approach particularly effective in addressing this issue by allowing for deeper engagement with the material outside of class.
Laupichler et al. (2022)	A seven-month course used a flipped classroom approach and was divided into two sections. The first section consisted of online self-study content. The second section involved interactive virtual classroom sessions. For the final assignment, students appeared on video to explain the subject matter.	- Half of the participants rated the overall course as "very good." - Participants preferred online self-study content over the classroom lessons that involved active learning. However this difference was not statistically significant. - The flipped classroom learning approach increased participants' understanding and application of AI in the medical field.

Experiential & Project-Based Learning		
Author(s)	**Learning Tasks**	**Key Findings**
Kong et al. (2023)	A 14-hour course involved lectures, group discussions, and project work to help students apply their understanding of ethical dilemmas and principles in AI development. Students worked in groups to develop AI platforms addressing real-world challenges. For instance, one group created a mindfulness chatbot that incorporated ethical safeguards, such as filtering harmful content, protecting user privacy, and avoiding intrusive questions.	- The three AI courses enhanced participants' AI literacy. The content covered in Course 1 and Course 2 equipped the participants with a conceptual understanding of AI, which built a framework for discussing ethics in Course 3. - Participants from diverse study backgrounds experienced significant progress in grasping AI-related concepts. - Project work was a useful approach for understanding AI concepts and deepening participants' ethical awareness related to AI. - Project work enabled participants to apply their knowledge, have hands-on experience, and consider ethical issues related to AI application development.
Tzirides et al. (2024)	An eight-week course incorporated project-based learning. Students selected AI-related topics to write essays, receiving feedback from both GenAI and human reviewers throughout the process. They then used GenAI image-generation tools to create visual artifacts representing their experience with the AI review process. Finally, students wrote reflections describing their creative process and the GenAI tools used.	- Exposure to AI tools, such as the AI review tool and AI-generated images, enhanced participants' interest in applying AI in their academic and professional fields, while also increasing their confidence in using AI technologies. - Despite generally positive attitudes toward AI, participants expressed concerns about privacy, security, and the accuracy of AI-generated feedback, highlighting the need for critical engagement with AI tools. - Participants demonstrated growth in their understanding of AI concepts and literacy. - Participants found both AI-generated and peer feedback valuable for knowledge acquisition, suggesting that integrating AI into review processes supports AI literacy development.
Liao et al. (2024)	A four-week course employed project-based and experiential learning with immersive technologies (e.g., AR/VR). The experimental group received AI literacy education through AR/VR integration and participated in physical field activities within AI experience and practice workshops. The control group attended similar workshops but without AR/VR components or additional field activities.	- Participants in the experimental group using the AR/VR digital learning platform showed significant improvements in AI-related knowledge and applications. - Both the experimental and control groups improved their academic performance, but the AR/VR teaching approach, combined with experiential and project-based learning, had a stronger impact. - Participants in the experimental group demonstrated a significantly better learning attitude after using the AR/VR platform, making them more interested and excited to learn about AI. - Participants in the experimental group reported greater satisfaction with their learning experience compared to the control group, highlighting the effectiveness of immersive AI literacy education.

Problem-Based Learning		
Author(s)	**Learning Tasks**	**Key Findings**
Naamati-Schneider (2024)	A twelve-week course was delivered using problem-based and self-directed learning approaches. At the start, students were introduced to ChatGPT to build understanding and proficiency. They then examined the hospital accreditation dilemma by conversing with ChatGPT, posing questions, and critically analyzing responses from organizational, healthcare worker, and patient/customer perspectives. Students documented their learning in reflective journals throughout the course.	- Participants recognized that while ChatGPT provided objective data, it required them to critically interpret and form their own arguments. - The use of ChatGPT positively impacted participants' digital literacy and helped develop their AI literacy skills, demonstrating the tool's effectiveness in supporting learning. - Participants found ChatGPT easy to use but noted challenges in mastering effective prompting to obtain accurate and desired responses.

Table 3.5

Charted Data for Topics and Content Covered

Author(s) & Year	Topics and Content Covered
Chen & Zhang (2024)	General overview of AI systems (e.g., the concept of AI); The artificial neural network; Multilayer neural networks; Using AI to solve problems of business intelligence systems; Hopfield networks and associative networks; Genetic algorithms; AI system for data retrieval and TextMining; Ethical issues regarding AI and its development
Hu et al. (2023)	AI training was integrated into an existing competency-based medical education (CBME) curriculum. The workshop covered: 1) Foundational AI concepts (e.g., AI, machine learning, deep learning), 2) Strengths and limitations of AI technologies in the medical field, and 3) Data science/AI theory, best practice guidelines, programming concepts.
Kim et al. (2023)	Artificial Intelligence of Things (AIoT) was the main topic (e.g., foundational concepts and theories related to AI). No other information regarding specific content covered.
Kong et al. (2023)	Course 1: Overview of AI's development & AI-related concepts (e.g., strong vs. weak AI, machine learning); Course 2: Deep learning, data cleaning, data augmentation, neural networks; Course 3: AI applications, ethical dilemmas, and principles of ethics related to AI
Kong et al. (2022)	Course 1: Overview of AI's development, AI-related concepts (e.g., strong vs. weak AI, machine learning), and AI's potential impact on society; Course 2: Deep learning, data cleaning, data augmentation, neural networks; Course 3: AI applications, ethical dilemmas, and principles of ethics related to AI
Kong et al. (2021)	The course covered four major concepts: AI, machine learning, supervised learning, and unsupervised learning across three courses: Course 1: Concepts related to machine learning; Course 2: AI concepts related to deep learning; Course 3: Problem-solving with AI & developing AI applications
Laupichler et al. (2022)	AI and medical imaging (e.g., how AI is/will be used in the diagnostic process using medical imaging data); Risks and opportunities of AI in medical imagining; The future of physicians in the context of AI
Liao et al. (2024)	AI in smart homes, smart factories, drones, robots, and smart libraries; Machine learning principles; AI applications in various fields (e.g., entertainment, medical care, transportation)
Lin et al. (2021)	History of AI; Supervised and unsupervised learning; Applications in AI; Problem-solving with AI; Ethical issues regarding the development of AI
Naamati-Schneider (2024)	Teaches a course titled "Introducing Quality into the Health System" using a ChatGPT-assisted online guided learning; Familiarization with ChatGPT, including detailed instructions on effective usage and interactive dialoguing with ChatGPT; Ethical dilemmas related to the hospital accreditation process through conversations with ChatGPT
Strubberg et al. (2024)	How technologies, such as ChatGPT, may support student engagement in the writing process; AI in the context of business, privacy, identity, content creation, filmmaking, and the dead internet; History of technologies, including AI, and ethics
Tzirides et al. (2024)	Machine vs. human learning, including AI's capabilities and implications in student learning

Table 3.6

Charted Data for Digital Tools Used to Facilitate Learning

Author(s) & Year	Digital Tools Used
Chen & Zhang (2024)	Not specified.
Hu et al. (2023)	Google Colaboratory was used by participants to execute code and to train decision tree classifier models to predict medical imagining data.
Kim et al. (2023)	Padlet for Question & Answer (Q&A) for out-of-class discussions (experimental group). No information regarding which program(s)/platform(s) were used for hands-on activities.
Kong et al. (2023)	Collaborative project work focused on developing/training AI models using tools such as Microsoft Azure Machine Learning Studio, Google Teachable Machine, and Microsoft Azure QnA Maker.
Kong et al. (2022)	Collaborative project work focused on developing/training AI models using tools such as Microsoft Azure Machine Learning Studio and Microsoft Azure QnA Maker.
Kong et al. (2021)	k-nearest neighbours (KNN) algorithm and decision trees were used to help participants understand how these models classify items into multiple categories.
Laupichler et al. (2022)	Not specified.
Liao et al. (2024)	AR/VR technology was used to facilitate experiential and project-based learning
Lin et al. (2021)	Custom Vision by Microsoft Azure was used to create an AI model for image recognition and classification. A motor-controlled car kit was used to design another model that would drive the wheels under different circumstances/traffic rules (e.g., the car would turn right if the car 'saw' a right-turn sign).
Naamati-Schneider (2024)	ChatGPT
Strubberg et al. (2024)	Gen AI platforms (names of platforms were not specified). Chatbots (e.g., ChatGPT)
Tzirides et al. (2024)	The AI review tool was integrated with OpenAI's GPT through an application programming interface (API). GenAI image generation tools, such as DALL-E, Midjourney, and Stable Diffusion, were used to evaluate participants' prompt engineering skills as well as their perceived usefulness of AI image generation tools for their learning experience.

Chapter 4. Discussion

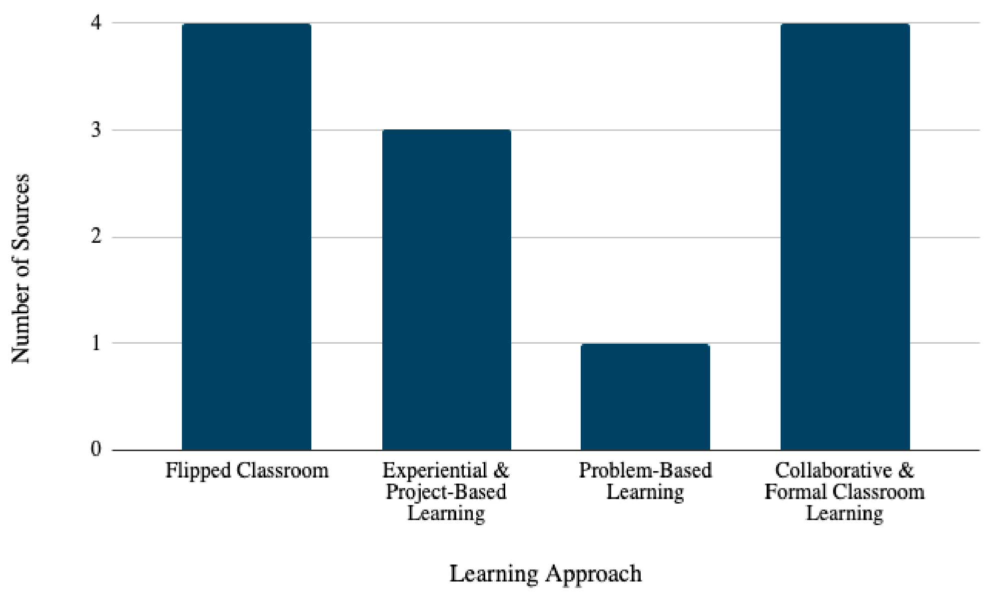
4.1 Summary of Evidence

This scoping review aimed to identify literature from the past five years related to the teaching and learning practices in post-secondary education aimed at developing students' AI literacy. The objectives were to explore the promising teaching and learning approaches applied, the topics covered, the digital tools used to support learning, and the outcomes of students' learning experiences. In addition, this scoping review sought to uncover gaps in the literature to reveal areas that are in need of further research. Of the 12 sources of evidence included in this review, most were published in the year 2024. It appears that there is a steady increase in the volume of literature published regarding this scoping review's focus, and this is likely to expand as research evolves. Regarding the type of literature found, the majority of the sources of evidence consisted of empirical studies from peer-reviewed journals (n = 9). Mixed-methods research designs were commonly applied throughout the literature (n = 6), with only one study (Naamati-Schneider, 2024) relying solely on qualitative methods. Although mixed-methods research designs provide well-rounded insights through both qualitative and quantitative data, there is a lack of in-depth qualitative investigations exploring students' perspectives and learning experiences with AI literacy education. In terms of the geographic region of the sources of evidence, most of the sources originated from countries in Asia. The scarcity of research conducted in North American countries suggests a gap that warrants attention from higher education institutions in Canada and the United States. Several sources of evidence included students from diverse academic disciplines, revealing a growing effort to make foundational AI literacy accessible beyond traditionally STEM-focused programs. Three sources of evidence focused specifically on students pursuing medical and healthcare-related degrees (Hu et al., 2023; Laupichler et al., 2022b; Naamati-Schneider, 2024), demonstrating efforts to tailor AI literacy curricula to specific disciplines to enhance relevance for students. A variety of learning approaches were employed, namely flipped classroom learning, experiential and project-based learning, problem-based learning, and collaborative and formal classroom learning (See Figure 4.1).

In general, the learning approaches mentioned above contributed to enhanced AI literacy development among post-secondary students, each with varying impacts on their learning experiences. Drawing on the results from the included sources of evidence, the learning approaches can be ranked according to their relative impact on students' AI literacy development. Project-based learning was identified as the most impactful approach, as students reinforced their theoretical understanding of AI concepts through direct application, which further enhanced their ethical awareness. The flipped classroom approach followed closely, demonstrating its effectiveness for building students' understanding of AI concepts independently and at their own pace. Since AI is a rapidly evolving topic, providing students with opportunities to engage with learning material outside of class time allowed them to process complex content and promoted self-directed and inquiry-based learning, which were important when learning about AI (Kong et al., 2021; Kong et al., 2022). Collaborative and formal classroom methods, particularly through case-based learning, encouraged reflection on AI's broader implications, although its impact was less pronounced among high AI-literate learners. Finally, problem-based learning appeared to have the least influence, primarily due to the limited number of studies employing this approach, which restricted the ability to gauge its effectiveness. In addition, the application of problem-based learning was confined to healthcare management students, whereas the other learning approaches were implemented across a diverse range of disciplines.

Figure 4.1

Distribution of Learning Approaches



4.2 Key Findings

To further expand on how the findings from the sources of evidence can inform future AI literacy initiatives, the following sections are organized around key implications for research and practice. The themes reflect recurring patterns across the literature and highlight practical strategies for supporting students' learning, while uncovering gaps in the literature that require further investigation. Framing the discussion in this way aims to provide educators, curriculum developers, instructional designers, and researchers with recommendations to enhance the future design and delivery of AI literacy in post-secondary education.

4.2.1 Promote Active and Student-Centered Learning

Throughout the literature, the value of integrating hands-on, reflective, and collaborative learning opportunities were an integral element of cultivating students' AI literacy. Active and student-centered learning was reflected in flipped classroom models, project-based, hands-on workshops, and group-based learning activities. Chen and Zhang (2024) suggested that collaborative classroom activities may have facilitated peer-to-peer knowledge exchange and active participation among students. Through peer learning, students gained a deeper understanding of the course content and developed AI literacy through a social context (Chen & Zhang, 2024). This sociocultural approach to learning encouraged students to explore diverse perspectives in co-constructing their understanding of AI (Chen & Zhang, 2024). For educators and instructional designers, this finding reinforces the need to move beyond passive instruction and intentionally structure learning around collaboration. Furthermore, activities that enable students to have hands-on experience support their understanding of AI concepts. For instance, Kong et al. (2022) identified that hands-on workshops helped students deepen their understanding of AI, leading to a preference to have more workshops. Students noted that the workshop activities, which involved interacting with various AI models, had reinforced their understanding of the course concepts (Kong et al., 2022). The flexibility of AI literacy programs is another notable implication related to students' learning experiences and AI literacy development. The flipped classroom model, in particular, was associated with high levels of student satisfaction (Kim et al., 2023; Laupichler et al., 2022b), especially as it allowed students to explore complex AI topics independently and in greater depth during self-study components (Kong et al., 2021). In addition, the flipped classroom model was regarded for its ability to help develop self-regulated learners, increase in-class participation, and instil the habit of preparing before class (Kong et al., 2021). These findings demonstrate that students may benefit from the opportunity to process and engage with AI content at their own pace before applying their knowledge during class time. Across the literature, students applied their knowledge of the ethical and societal implications of AI primarily through project work. Kong et al. (2023) showed that when students built AI models as part of their project work, it helped them reflect on human-AI relations and the societal responses to AI-driven change. In addition, the project work allowed students to consider ethical principles that were not directly addressed in the course, such as privacy and transparency (Kong et al., 2023). Similarly, Lin et al. (2021) found that students' understanding of AI, along with the ethical issues, significantly improved when tasked with developing and training AI models, especially when this task was completed in groups. Collaborative activities helped students recognize the importance of teamwork in solving AI-related issues, which is essential for becoming AI literate (Lin et al., 2021).

4.2.2 Centre Ethics in AI Literacy

Although most of the sources of evidence addressed AI ethics, not all AI literacy programs integrated it as a core component. The inconsistency of embedding the ethical and societal implications of AI may stem from the lack of a universally accepted definition of AI literacy and varied interpretations of what competencies should be assessed. Overlooking ethics in AI education risks producing technically proficient students who lack critical awareness of the broader implications of AI's impact on society. In the sources of evidence that addressed AI ethics, the findings reflected a more holistic development of students' AI literacy. Lin et al. (2021) reported that students with higher AI literacy exhibited significantly greater awareness of what they identified as the four dimensions of ethics (transparency, benefit, justice, and responsibility), as measured by the study's assessment instrument. Few AI literacy programs focused narrowly on foundational understanding. For instance, Liao et al. (2024) centred their AI literacy curriculum on smart technologies and machine learning principles, but did not extend the discussion to the ethical or societal impacts. In other cases, ethical considerations were only briefly introduced, leading to limited student understanding. Laupichler et al. (2022b) found that students acquired a surface-level understanding of the ethical implications of AI in medical contexts, largely because insufficient time was devoted to discussing this critical aspect of AI literacy. Similarly, while Lin et al. (2021) included ethics as a core concept, they suggested that students may need prolonged exposure to AI ethics to strengthen their ethical awareness further. Future researchers and practitioners should ensure that ethics is explicitly embedded within the curriculum and enough time is dedicated to this topic to enable students to reflect on the societal consequences of AI and evaluate real-world ethical dilemmas. In addition, the complexity of AI ethics may require careful consideration related to how this topic is taught. For example, students found that the self-directed components in the flipped classroom model hindered their understanding of AI ethics, as students required real-time instructor support and guidance (Kong et al., 2022). Educators and instructional designers may consider leveraging approaches that have had more success, such as developing AI models through project work, to aid students in navigating more complex topics. Alternatively, teacher-directed strategies, such as structured debates, case analyses (Lin et al., 2021), and teacher-facilitated discussions, can provide students with timely guidance and support, helping to reduce the barriers of self-directed approaches.

4.2.3 Leverage AI-Driven Technologies

Direct engagement with AI-based tools served as practical applications that strengthened students' AI literacy through technical understanding and critical evaluation. In addition, leveraging AI tools can help students better understand abstract concepts by making them more tangible than through theory alone. Google's Teachable Machine, Microsoft Azure's Custom Vision, Machine Learning Studio, and QnA Maker emerged as commonly used tools that introduced students to foundational machine learning concepts and were used to develop and train AI models. Both Kong et al. (2023) and Lin et al. (2021) highlighted that embedding AI-driven tools in learning activities significantly deepened students' conceptual understanding of AI technologies and encouraged them to consider how these technologies are developed and their broader implications. Other studies implemented GenAI platforms, such as ChatGPT, Midjourney, and DALL-E, to provide students with hands-on experience of these emerging technologies. Naamati-Schneider (2024) found that interacting with ChatGPT encouraged students to evaluate AI-generated content by verifying the outputs rather than passively accepting them. Students also valued ChatGPT for its accessibility and ease of use (Naamati-Schneider, 2024), highlighting its utility as a valuable entry point for introducing learners to GenAI. Furthermore, the iterative process of refining prompts helped students to become aware of GenAI's limitations, including the potential for biased and inaccurate information (Naamati-Schneider, 2024). Tzirides et al. (2024) echo the importance of human oversight in AI use, noting that students' interactions with GenAI feedback and image generation tools enabled them to become more aware of maintaining human judgment while engaging with AI. While leveraging AI-based technologies supports students' AI literacy development, it is suggested that exposure to general-purpose AI tools alone is insufficient (Tzirides et al., 2024). Educators should ensure that students engage with AI tools that are tailored to their disciplinary contexts. Future research may explore how specific AI tools influence post-secondary students' critical thinking, ethical awareness, and overall development of AI literacy.

4.2.4 Provide Differentiation

Differentiating instructional approaches based on students' prior knowledge of AI emerged as a subtle, yet important consideration. Lin et al. (2021) found that students with lower levels of AI literacy demonstrated more substantial gains from the course that combined independent and group-based AI model training activities, compared to their peers with higher AI literacy. Additionally, the case studies introduced throughout the course were found to be less effective for students who already possessed a strong understanding of AI ethics. Lin et al. (2021) further recommended customizing more challenging activities for advanced learners to enhance their ethical awareness, suggesting that the absence of differentiation in the learning activities may have contributed to the uneven gains observed. Chen and Zhang (2024) also suggested that scaffolding should be provided when introducing AI concepts to novice learners. A gradual introduction to AI terminologies with real-world examples of each is crucial to consider when teaching AI to non-technical learners to support their comprehension (Chen & Zhang, 2024). Based on these findings, future research may investigate how differentiated learning activities may be adapted to address the diverse needs of learners with varying levels of AI literacy. Educators and instructional designers may consider incorporating tiered activities to support beginner learners while challenging the more advanced learners. By adopting such differentiation in both the content and activities, AI literacy programs can be optimized to effectively support diverse learners.

4.2.5 Contextualize Content to Promote Relevance

The findings from this scoping review indicate that the content of AI literacy programs were often tailored to students' disciplinary backgrounds, which made the content more relevant to students' interests and future careers. For instance, students in healthcare-related fields explored AI concepts through medical case studies and clinical applications (Hu et al., 2023; Laupichler et al., 2022b; Naamati-Schneider, 2024). Laupichler et al. (2022b) found that the majority of the students who participated in the AI literacy program were motivated because the program was aligned with their field of radiology, making the content feel especially applicable to their future careers. Although students from other academic disciplines received broader AI education, the AI literacy programs covered foundational AI concepts as well as the implications of AI in personal, academic, and professional contexts. Strubberg et al. (2024) note that students expressed increased confidence and enthusiasm when they had autonomy to explore AI topics that aligned with their interests and academic backgrounds. In addition, students preferred to have the same autonomy when completing learning activities (Strubberg et al., 2024). These findings suggest that personalized learning experiences may enhance the effectiveness of AI literacy instruction. Future AI literacy programs may consider embedding discipline-specific learning materials and activities to promote relevance and engagement.

4.2.6 Consider Delivery Mode

The delivery mode of AI literacy programs appeared to influence students' learning experiences, particularly when the programs were delivered virtually. For example, Laupichler et al. (2022b) identified that students preferred the asynchronous, self-paced content over synchronous learning sessions. However, this preference may have been shaped by the fact that classroom activities were conducted online due to COVID-19 restrictions. In addition, the final assignment, in which students recorded themselves explaining AI-related topics in radiology, was rated significantly lower than both the self-paced and synchronous components. Having to appear on camera and reiterate the course material may have placed students in an uncomfortable and potentially intimidating situation (Laupichler et al., 2022b), further highlighting how virtual delivery formats may impact students' willingness to participate in activities. Similarly, Kong et al. (2023) acknowledged that the remote teaching context during the pandemic may have affected students' learning and participation. Although Hu et al. (2023) delivered their program virtually, they did not explicitly examine how this modality might have impacted student learning. These findings suggest that the delivery mode may shape how students engage with and benefit from AI literacy initiatives. As such, educators and instructional designers should carefully consider how to adapt interactive and collaborative components of AI education for virtual environments while sustaining engagement. Future research might also investigate whether different delivery modes support or hinder specific learning outcomes.

4.2.7 Gaps in the Literature

Despite the valuable insights that emerged from this scoping review, several gaps in the literature remain. First, across the reviewed literature, there appeared to be no universally accepted or standardized instrument for assessing students' AI literacy. Although many sources of evidence utilized pre- and post-tests and surveys to measure students' conceptual knowledge, confidence, or ethical awareness, the instruments varied in structure, focus, and reported reliability. In addition, the absence of a universally applied assessment instrument may be related to the inconsistent definitions of AI literacy across the sources of evidence. Although AI literacy was commonly referred to as the ability to understand, evaluate, and use AI ethically, the specific components and emphases differed across the sources of evidence. Future research may prioritize the development of comprehensive, validated, and contextually adaptable assessment tools that capture the multifaceted nature of AI literacy. Second, while many sources of evidence reported positive short-term outcomes, such as increased awareness of AI concepts and improved ethical understanding, the long-term impacts of AI literacy education are left unanswered. As AI technologies continue to evolve and permeate aspects of society, it remains unclear whether students retain and apply the knowledge and skills they acquired over time. Future research should investigate how AI literacy initiatives influence students' ability to transfer their knowledge into new domains, including professional settings and ongoing educational pursuits. Third, the limited use of problem-based learning reveals another gap in the literature, given that only one source of evidence in this review adopted a fully problem-based model. Although the problem-based learning approach was found to cultivate deeper inquiry and real-world problem-solving (Naamati-Schneider, 2024), there is an opportunity for future research to explore how this approach might strengthen students' ability to navigate complex challenges brought on by AI. The delivery mode of AI literacy initiatives was identified as another gap, given that only two sources of evidence explicitly addressed how virtual delivery may have shaped students' learning experiences. To recall, both Laupichler et al. (2022b) and Kong et al. (2023) identified that pandemic-related disruptions may have influenced students' learning and participation in course activities. Lastly, there is a lack of research on discipline-specific AI literacy instruction. While some programs were tailored to students' fields of study, many initiatives offered general or one-size-fits-all approaches. Further exploration is needed to determine how aligning AI literacy content with students' academic contexts may improve engagement, relevance, and learning outcomes.

4.3 Limitations

According to the PRISMA-ScR guidelines, because a critical appraisal of sources is optional for scoping reviews and was not pursued, the limitations should focus on the review process itself rather than on the included sources of evidence (Tricco et al., 2018). However, in an effort to provide greater contextual insight into the findings, this section discusses both the limitations of the included sources of evidence and the limitations of the scoping review process. Acknowledging both of these limitations helps clarify the extent to which the findings may be generalizable or transferable across various educational settings.

The authors of the included sources of evidence reported the following set of limitations, offering important context for evaluating the scope and applicability of the findings. Few sources recruited participants from a single higher education institution (Chen & Zhang, 2024; Hu et al., 2023; Kong et al., 2021), while others involved participants from the same program (Hu et al., 2023; Naamati-Schneider, 2024). The recruitment of participants from the same institution or program reduces the generalizability of the findings to broader education settings and may reflect the possibility of selection bias. Similarly, Kim et al. (2023) noted that their findings were specific to Korean learners, which may impact the transferability of the results beyond this specific context. Relatively small sample sizes were another frequently cited limitation (Kim et al., 2023; Hu et al., 2023; Laupichler et al., 2022b; Tzirides et al., 2024), further constraining the generalizability of the results. Other sources recognized the absence of longitudinal data, which made it difficult to track participants' knowledge retainment over time (Hu et al., 2023; Tzirides et al., 2024). In addition, response bias may have been present due to the reliance on self-reported data, and the lack of a control group hindered the ability to determine causality (Chen & Zhang, 2024; Tzirides et al., 2024). Four of the sources of evidence did not report on the limitations of their work (Kong et al., 2022; Liao et al., 2024; Lin et al., 2021; Strubberg et al., 2024), raising concerns about the transparency and credibility of their findings. Finally, three studies did not clearly separate the specific influence of the pedagogical approaches on students' AI literacy development. Instead, they reported overall improvements in AI literacy without specifying whether these gains were mainly due to the teaching methods, the course content, or other contributing variables (Hu et al., 2023; Kim et al., 2023; Liao et al., 2024).

This scoping review was subject to limitations. First, although the PRISMA-ScR guidelines were used to provide guidance on the reporting process, not all items were followed. For instance, a review protocol was not registered prior to beginning the data collection and analysis. The absence of a predefined protocol may have reduced the transparency and reproducibility of the review process and introduced a potential risk of outcome reporting bias (Tricco et al., 2018). Additionally, without a registered protocol, it is difficult to confirm whether a similar or duplicate review was already underway at the time of conducting this scoping review. Second, a critical appraisal of the individual sources of evidence and a critical appraisal of the sources of evidence were not undertaken. While PRISMA-ScR guidelines state that these items are optional, a critical appraisal is typically completed if it aligns with the scoping review's objectives (Tricco et al., 2018). Since the aim of this scoping review was to explore the extent of existing literature, a critical appraisal fell outside the scope of this review. Lastly, the search for relevant literature, the screening and selection of eligible sources, and data charting were conducted independently. The lack of multiple reviewers could have potentially limited the consistent application of the eligibility criteria, as this process was left to subjective judgment. Although measures were taken to ensure consistency throughout the scoping review process, there is a possibility that interpretive bias was introduced.

Chapter 5. Conclusions

5.1 Summary of Findings

The rapid advancement of AI necessitates that digital citizens acquire AI literacy in order to participate meaningfully in a society that is increasingly influenced by these technologies. As AI evolves, post-secondary institutions hold a critical responsibility to prepare students to navigate, evaluate, and collaborate with AI effectively (Kurtz et al., 2024; Rasky, 2024). The significance of this scoping review lies in its research-informed considerations that may shape the design and implementation of post-secondary AI literacy initiatives. Based on the findings from the 12 sources of evidence, this review revealed several implications to support students' development of AI literacy skills. To recall, these implications were to: promote active and student-centered learning; provide scaffolded support when discussing AI ethics through teacher-facilitated methods; incorporate activities that encourages students to explore, evaluate, and develop AI technologies; provide differentiation to accommodate students' prior knowledge by offering tiered tasks or supplementary resources for novice learners, and more complex activities, such as debates or case analyses (Lin et al., 2021), for advanced learners; and contextualize content to learners' personal and professional interests to promote relevance.

In terms of promising pedagogical approaches, this scoping review found that collaborative, project-based, and flipped classroom learning environments were effective in developing students' AI literacy skills in post-secondary education. Rather than adopting a one-size-fits-all intervention, educators and instructional designers may draw on the strengths of each approach to create flexible and responsive learning experiences.

Important topics to cover in any AI literacy program may include: basic AI terminologies, such as machine learning, strong versus weak AI, while providing students with real-world examples of each term (Chen & Zhang, 2024); a discussion of AI's impact on society; and the ethical implications associated with AI, as ethical awareness is seen as a core component of AI literacy (Ng et al., 2021a). In addition, the content should be contextualized to students' fields of study whenever possible to ensure relevance. Should the AI literacy program be offered in general education settings, students may explore tailored content that aligns with their personal, professional, or disciplinary interests. AI literacy initiatives may incorporate learning activities that combine self-directed and collaborative learning. Students may build their knowledge of AI at their own pace by engaging with AI-related literature, videos, and inquiry-driven discussions (Strubberg et al., 2024), which have been found to support students' conceptual understanding (Kong et al., 2021). Educators can then facilitate structured discussions to scaffold complex topics, such as AI ethics, and gradually transition to student-led discussions, debates, and other collaborative activities as learners gain confidence with the material (Chen & Zhang, 2024; Lin et al., 2021). This scaffolding can prepare students to translate theory into practice through problem- and project-based learning activities, including exploring, evaluating, and creating AI technologies (Lin et al., 2021; Kong et al., 2022; Kong et al., 2023; Naamati-Schneider, 2024; Strubberg et al., 2024). For instance, students could explore Google's Teachable Machine to visualize machine learning principles, leverage ChatGPT to evaluate the accuracy of GenAI outputs, or utilize Microsoft Azure platforms to create their own AI models.

5.2 Avenues for Future Research

While the above recommendations offer promising practices, the limitations reported by the studies inform future research directions. The delivery mode of AI literacy interventions warrants further investigation, as only two studies acknowledged that the virtual delivery mode may have had an impact on students' learning (Laupichler et al., 2022; Kong et al., 2023). Future research may seek to examine how different modalities, including fully online, hyflex, and in-person instruction, shape AI literacy development in post-secondary contexts. To improve the trustworthiness, credibility, dependability, and transferability of the findings, studies should recruit participants across multiple institutions and cultural contexts rather than single institutions or countries (Chen & Zhang, 2024; Hu et al., 2023; Kim et al., 2023; Kong et al., 2021; Naamati-Schneider, 2024). In addition, longitudinal and correlational studies may be viable avenues to uncover the long-term effects of AI literacy interventions and determine the impact between the instructional approaches and the course content in relation to students' AI literacy development. Incorporating control groups into future study designs could also help clarify the cause and effect of specific AI literacy interventions (Chen & Zhang, 2024; Tzirides et al., 2024). Finally, while the literature did not explicitly address how AI literacy initiatives may be adapted to support students with diverse learner backgrounds, there is a need for equity-focused research to explore inclusive approaches for students with disabilities and language barriers. In summary, these suggestions aim to advance the future body of literature related to AI literacy development in post-secondary settings.

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APPENDIX

Abandoned Search Strings

(“instructional design” OR “instructional practices” OR “course development” OR “instructional development” OR “instructional systems design” OR “curriculum planning” OR “curriculum development “ OR “curriculum frameworks”) AND (“artificial intelligence” OR “machine learning”) AND (“digital literacy” OR literacy OR “AI literacy”) AND (framework OR practices OR policy OR curriculum) AND (university OR college OR “higher education” OR “post secondary” OR postsecondary)

(“educational technology” OR “digital learning” OR EdTech OR EDUTech OR “instructional technology” OR “technology in education” OR “technology integration in education” OR “technology uses in education”) AND “artificial intelligence” AND (ethic* OR “academic integrity” OR plagiarism) AND (university OR college OR “higher education” OR “post secondary” OR postsecondary)

Multiple search strings were collaboratively developed with a subject librarian. The above search strings were later abandoned due to the lack of sufficient and eligible sources of information.