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SPECIAL TOPIC ARTICLE

AI literacy as a core component of AI education

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Abstract

As generative artificial intelligence (AI) becomes increasingly integrated into society and education, more institutions are implementing AI usage policies and offering introductory AI courses. These courses, however, should not replicate the technical focus typically found in introductory computer science (CS) courses like CS1 and CS2. In this paper, we use an adjustable, interdisciplinary socio-technical AI literacy framework to design and present an introductory AI literacy course. We present a refined version of this framework informed by the teaching of a 1-credit general education AI literacy course (primarily for freshmen and first-year students from various majors), a 3-credit course for CS majors at all levels, and a summer camp for high school students. Drawing from these teaching experiences and the evolving research landscape, we propose an introductory AI literacy course design framework structured around four cross-cutting pillars. These pillars encompass (1) understanding the scope and technical dimensions of AI technologies, (2) learning how to interact with (generative) AI technologies, (3) applying principles of critical, ethical, and responsible AI usage, and (4) analyzing implications of AI on society. We posit that achieving AI literacy is essential for all students, those pursuing AI-related careers, and those following other educational or professional paths. This introductory course, positioned at the beginning of a program, creates a foundation for ongoing and advanced AI education. The course design approach is presented as a series of modules and subtopics under each pillar. We emphasize the importance of thoughtful instructional design, including pedagogy, expected learning outcomes, and assessment strategies. This approach not only integrates social and technical learning but also democratizes AI education across diverse student populations and equips all learners with the socio-technical, multidisciplinary perspectives necessary to navigate and shape the ethical future of AI.

INTRODUCTION

Artificial intelligence (AI) technologies are proliferating at a faster pace than previous generations of digital innovations, creating an urgent need for a workforce prepared to enter AI-driven professional and social environments (Eynon and Young 2021). Some of the priorities that have gained traction (measured through the number of academic conferences, business growth, and policy-making actions) include the domains of large language model (LLM) creation and integration, computer vision-based technologies, AI safety, LLM modeling, natural language processing (NLP), robotics, reinforcement learning, autonomous systems, AI ethics and fairness, healthcare AI, financial AI, and edge AI (Benko and Lányi 2009; Černỳ 2024; Gunning and Aha 2019; Kaplan and Haenlein 2020; Ng et al. 2021b; Tadimalla and Maher 2024). At the intersection of these fields within AI and education, two distinct but related areas have emerged: *AI education* and *AI in education*.

"AI Education" focuses on building capacity for an AI workforce to meet current and future industry needs, while "AI in Education" focuses on leveraging AI to enhance classroom/education experiences by enabling personalized or adaptive learning (Chiu et al. 2023; Tadimalla and Maher 2024c). AI in education is currently driven by business and pedagogical motivations to create products for education and research funding focused on improving learning through the development of AI tools and systems. In this paper, we focus on AI education, which has evolved from foundational programming and algorithmic concepts to advanced data science and machine learning curricula (Kandlhofer et al. 2016; Schiff 2022)

Globally, approaches to AI education vary widely by region and culture, underscoring the importance of tailoring education efforts to local contexts (Williamson 2024). Current AI Education efforts have paralleled earlier capacity-building measures in the STEM fields of computer science, data science, and cybersecurity (Parrish et al. 2018). However, lessons from these STEM domains reveal persistent underrepresentation of marginalized groups, such as women and students from lower socioeconomic backgrounds, both globally and in the United States (Freeman, Adrion, and Aspray 2019; Secretary et al. 2023; Haigh 2023; Tadimalla and Maher 2024b). Pedagogical innovations in AI education to address these issues include an increase in active learning, service learning, and more engaging teaching methodologies to enrich students' mastery of AI concepts (Herodotou et al. 2019; Ng et al. 2023). Policy and regulatory frameworks have become pivotal to address these issues and shape AI education standards across the K-12 and post-secondary education levels (TeachAI and CSTA 2024; Touretzky et al. 2019). Ensuring that curricula remain both current and aligned with the evolving needs of industry and society has been identified as a common priority across both (Schiff 2022; Williamson and Eynon 2020).

Although technical proficiency remains fundamental and a broad priority, the recognition of the societal, ethical, and future implications of AI is increasing, and many curricula and courses are designed to integrate socio-technical perspectives. These sociotechnical considerations often focus on how to navigate issues of privacy, fairness, and bias within AI systems (Mouta, Torrecilla-Sánchez, and Pinto-Llorente 2023; Zhang et al. 2023). In many introductory AI courses, certificates, and programs, socio-technical components are confined to one or two modules. In the future, AI education is expected to adopt even more integrated and holistic models that combine technical skills with ethical and societal dimensions, thus preparing students for the multifaceted realities of AI in society (Laupichler et al. 2022). In response, within the broader landscape of AI Education, AI literacy as a subfield has emerged in multiple specialized forms. The field of AI literacy originally centered on educating the public on competencies that enabled individuals to critically evaluate and engage with AI technologies. Recently, AI literacy encompasses teaching AI concepts to diverse age groups and demographics, as well as exploring societal impacts and preparing students for future developments (Carolus et al. 2023; Long and Magerko 2020; Ng et al. 2021a). This paper consolidates these efforts and discusses the design and implementation of a socio-technical AI course that aims to equip learners with a balanced understanding of both AI's technical underpinnings and its wider impacts as a basis for additional courses in AI and areas related to AI, as shown in Figure 1.

COMPARING AI LITERACY TO AI EDUCATION

AI education refers to the structured teaching of AI concepts, techniques, and applications, designed to develop a broader pool of AI professionals and innovators. University programs—particularly in computer science and engineering—commonly offer specialized AI courses and degrees, supplemented by online platforms, workshops, and self-directed study options such as MOOCs and micro-credentials (Druga, Otero, and Ko 2022; Kong, Cheung, and Zhang 2021; Rodriguez 2012; Southworth et al. 2023). K-12 schools have also begun to introduce AI, aiming to familiarize younger students with foundational AI concepts; however, these efforts remain uneven across different regions and districts (Hollands 2024; Rainie 2022). Formal and informal AI learning pathways often center

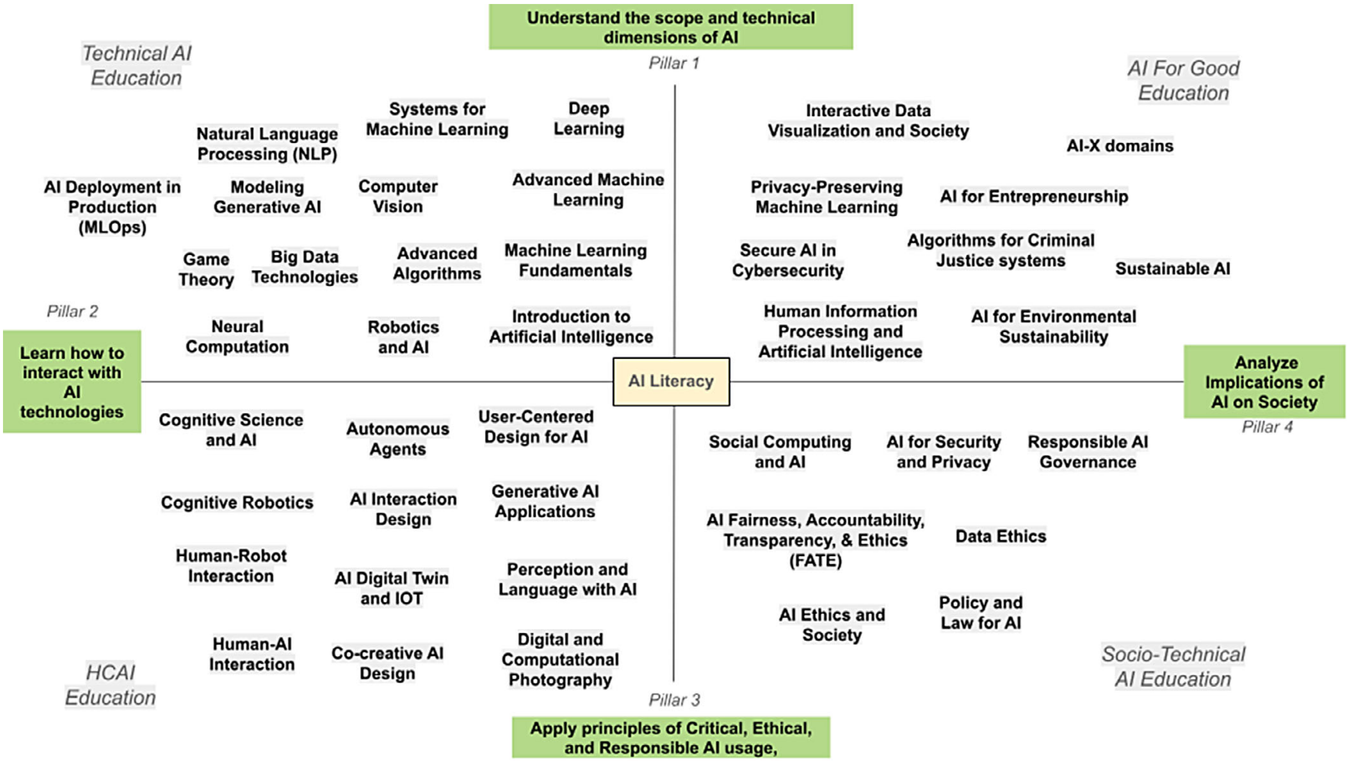

FIGURE 1 AI literacy is the core component for various AI education pathways, concentrations, and specializations.

on the technical side—encompassing algorithmic understanding, programming, and model building—while many professional training programs emphasize the practical application of AI tools in response to market demands (Dodero et al. 2021; Firth-Butterfield et al. 2022; Xia, Li, and Li 2024). Recent pedagogical approaches emphasize the integration of symbolic AI and deep learning techniques, highlight synergy with data science, and a commitment to ethics and responsible AI design (Kong, Cheung, and Tsang 2024; Laato et al. 2020; Maher and Tadimalla 2024; Tadimalla and Maher 2024; Zhang et al. 2023). While early AI education efforts have predominantly focused on technical expertise (Eaton and Epstein 2024; Kumar et al. 2024; Southworth et al. 2023), today's socio-technical context necessitates a more holistic strategy (Ge et al. 2024; Tadimalla and Maher 2024b).

AI literacy, building on digital literacy (Celik 2023), extends beyond technical expertise by encompassing the diverse knowledge and competencies needed to understand, interact with, and critically assess AI systems (Kandlhofer et al. 2016). This includes awareness of ethical and societal implications, such as biases, transparency, and privacy concerns that have intensified with the public availability of generative AI tools like ChatGPT (Chen 2023; Grover 2024; Touretzky et al. 2019). The technical expertise in this literacy-building approach is focused on building vocabulary and high-level understanding of the scope and technical dimensions of AI. Laying the foundation for a deeper form of knowing that one expects from AI professionals.

How AI literacy has evolved over the last 3 years can be organized into the following broad categories:

- *Technical AI literacy/education* targets core skills in programming, machine learning, and data science (Kreinsen and Schulz 2023; Ng et al. 2021b), making them available to non-CS/AI professionals.
- *General AI literacy* equips non-experts to critically and responsibly engage with broader AI technologies they encounter daily (Kong, Cheung, and Tsang 2024; Long and Magerko 2020),
- *Gen-AI literacy* focuses specifically on the potential benefits and risks of generative models (Chen 2023).
- *Ethical and Social AI literacy* tackles fairness, accountability, and transparency issues (Tadimalla and Maher 2024; Zhang et al. 2023),
- *Cognitive or Meta-cognitive AI literacy* enhances problem-solving, decision-making, and self-reflective capabilities in an AI-driven work environment.

There are also emerging areas of AI literacy which focus on virtual and augmented reality (VR and AR) environments (Cao and Dede 2023; Herath, Mittal, and Kataria 2024; Sokołowska 2023). There is also a jagged landscape

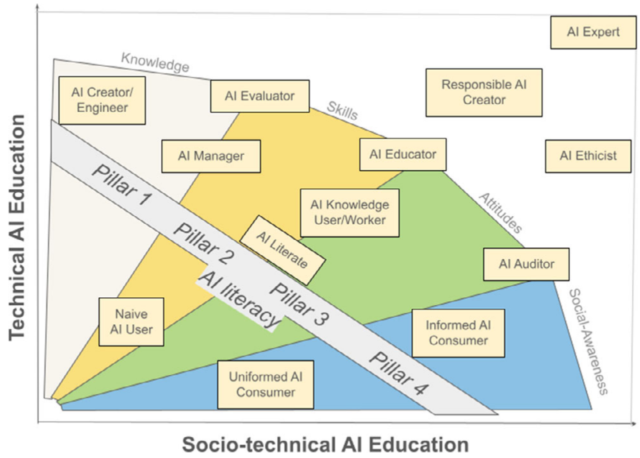

FIGURE 2 Educational pathways to different roles for AI professionals with AI literacy as the core.

AI	Artificial Intelligence
AL	Algorithmic Foundations
AR	Architecture and Organization
DM	Data Management
FPL	Foundations of Programming Languages
GIT	Graphics and Interactive Techniques
HCI	Human-Computer Interaction
MSF	Mathematical and Statistical Foundations
NC	Networking and Communication
OS	Operating Systems
PDC	Parallel and Distributed Computing
SDF	Software Development Fundamentals
SE	Software Engineering
SEC	Security
SEP	Society, Ethics, and the Profession
SF	Systems Fundamentals
SPD	Specialized Platform Development

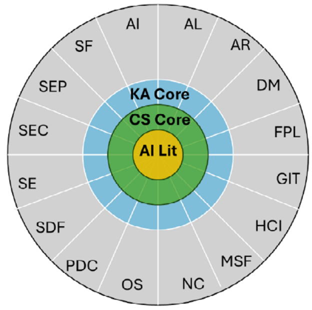

FIGURE 3 (left) The 17 knowledge areas that compose the CS2023 curriculum (Eaton and Epstein 2024). (right) An instantiation of the curriculum at a college or university as a program of study would follow a sunflower model, including the full set of CS core topics (in green) and selected other knowledge areas (the blue core plus additional elective topics in gray). We advocate for AI literacy (in yellow) to be a foundational element of education across all CS education pathways.

of efforts in directions that are focused on preparing for Artificial General Intelligence (Bikkasani 2024) and Agentic AI (Acharya, Kuppan, and Divya 2025). More comprehensive AI literacy initiatives—grounded in socio-technical principles—are emerging to address broader societal implications (Mills et al. 2024; Servin et al. 2024; Touretzky et al. 2019).

Central to our approach of positioning AI literacy at the core of AI education are the four curriculum pillars that structure AI literacy for all (Tadimalla and Maher 2024a). In this paper, we refine the previous version to reflect the current AI landscape and priorities (visualized in Figure 4):

- *Pillar 1*: Understand the scope and technical dimensions of AI,
- *Pillar 2*: Learn how to interact with (generative) AI technologies,
- *Pillar 3*: Apply principles of critical, ethical, and responsible AI usage, and
- *Pillar 4*: Analyze implications of AI on society.

The learning outcomes vary across these dimensions of technical proficiency and socio-technical awareness based on learner contexts (age, cultural, educational, and professional setting). Figure 2 illustrates how different roles—ranging from Naive AI Users to Responsible AI Creators—occupy distinct positions along these axes of AI knowledge, AI skills, AI attitudes, and perceptions. By mapping these roles onto the four pillars of AI learning (technical foundations, user-focused competencies, sociotechnical considerations, and ethical perspectives), we can better identify the pathways into AI as a field and the interventions needed to build comprehensive AI literacy to support those aspirations.

Motivations for a balanced socio-technical AI course framework to introduce the field of AI to new learners or an introductory AI literacy course also stem from lessons in CS education, particularly the drive to make introductory courses more inclusive and mitigate "gateway" barriers (e.g., CS1 and CS2) (Hollands 2024). Intervention programs, such as summer camps and bridge courses, and teaching practices like active learning, project-based learning, and inclusive pedagogies, have helped broaden participation and sense of belonging among underrepresented groups (Druga et al. 2019; Schüller 2022). Incorporating diversity, equity, and inclusion principles can be beneficial for aligning curricula with ethical standards and industry demands (Alvarez et al. 2022; Cachat-Rosset and Klarsfeld 2023; Casal-Otero et al. 2023; Shams, Zowghi, and Bano 2023).

The development of socio-technical AI education merges traditional AI literacy (e.g., ethics, privacy, social implications) with core AI educational principles, emphasizing responsible use and accountability. Learners not only master AI techniques but also understand the larger influence of AI on society and daily life, strengthening AI as a foundational skill of literacy of the 21st century (Kong, Cheung, and Zhang 2021; Long and Magerko 2020; Ng et al. 2021b; Stolpe and Hallström 2024; Yue, Jong, and Dai 2022).

By centering AI literacy in the core—alongside foundational CS topics (see Figure 3), institutions can ensure graduates are not only technically proficient but also capable of understanding and addressing the broader societal, ethical, and practical dimensions of AI. This integrated approach ultimately empowers learners to become well-rounded professionals who can contribute meaningfully to the evolving landscape of AI-driven innovation.

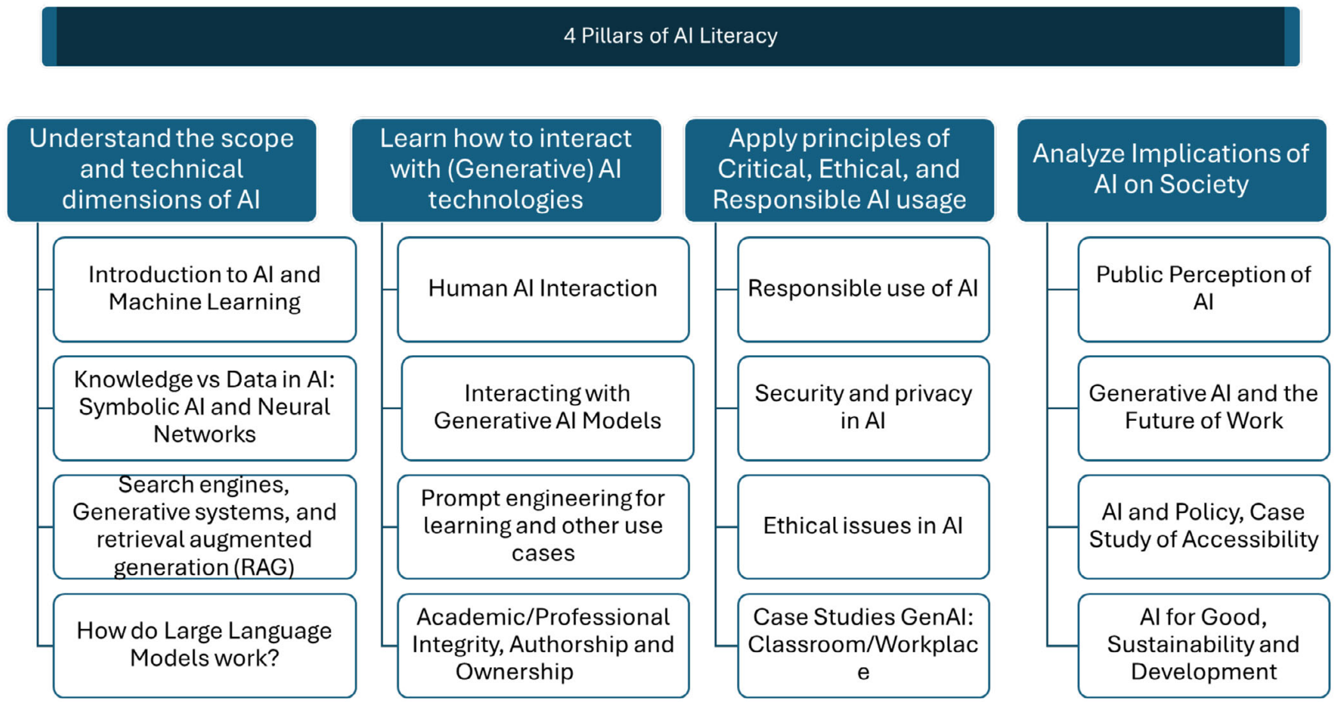

FIGURE 4 Four pillars of AI literacy mapped to subtopics.

AI LITERACY COURSE FRAMEWORK

In this section, we elaborate on the concepts taught across the 16 modules as shown in Figure 4. Previous work and exploratory literature on some of the components of these modules for further exploration can be found in Tadimalla and Maher's (2024) research on the AI ecosystem (Tadimalla and Maher 2024) and AI literacy for All (Tadimalla and Maher 2024a). The original "AI literacy for All" framework presents a curriculum approach which maps the knowledge areas and learning outcomes across the education levels and learner groups (K-12, Higher education, Working Professionals, and Civic citizens). Where each instantiation of the course is customized for the learner population and contexts, with varying emphasis on subtopics across the modules. This paper builds on that approach and updates each Module in terms of the topics and expected learning outcomes (see Figures 5–8). We have integrated case studies for modules under Pillars 3 and 4, which allows the learners who have engaged in vocabulary building and understanding of AI technologies under Pillar 1 and Skills and understanding of the AI tools functioning from Pillar 2, to make connections between the technical content and the ethical/social inquiries under Pillars 3 and 4. The course materials integrate content from diverse resources such as textbooks, online courses, academic papers, and interactive tools. These materials include online videos (e.g., Code.org, IBM Technology Platform), plug-and-play applications, sample codes for LLM API integration (Shen et al. 2024), news and policy articles, and access to platforms like DeepLearning.AI, Coursera, and edX to adapt the course for different contexts. Hands-on tools such as Jupyter Notebooks and Google Colab can significantly enrich the learning experience. We acknowledge the pressing need for evaluation and assessment research in AI literacy across different age groups to tailor educational strategies effectively (Tadimalla and Maher 2024c). Integrating this course framework into various disciplines can be achieved by creating modular components that highlight domain-specific AI applications (Knoth et al. 2024). This approach ensures that the AI literacy course remains flexible, comprehensive, and accessible, catering to the diverse educational needs of students across various fields.

Module 1: Introduction to AI and machine learning

This module provides a comprehensive overview of AI by covering its fundamental concepts, subfields, applications, and historical development. Students begin by exploring what AI is, including its ability to simulate human intelligence through tasks such as learning, reasoning, problem-solving, perception, and language understanding. The module then discusses various subfields of AI, including machine learning, NLP, robotics, computer vision, reinforcement learning, and AI ethics and fairness.

Applications of AI in domains such as healthcare, finance, education, transportation, entertainment, and

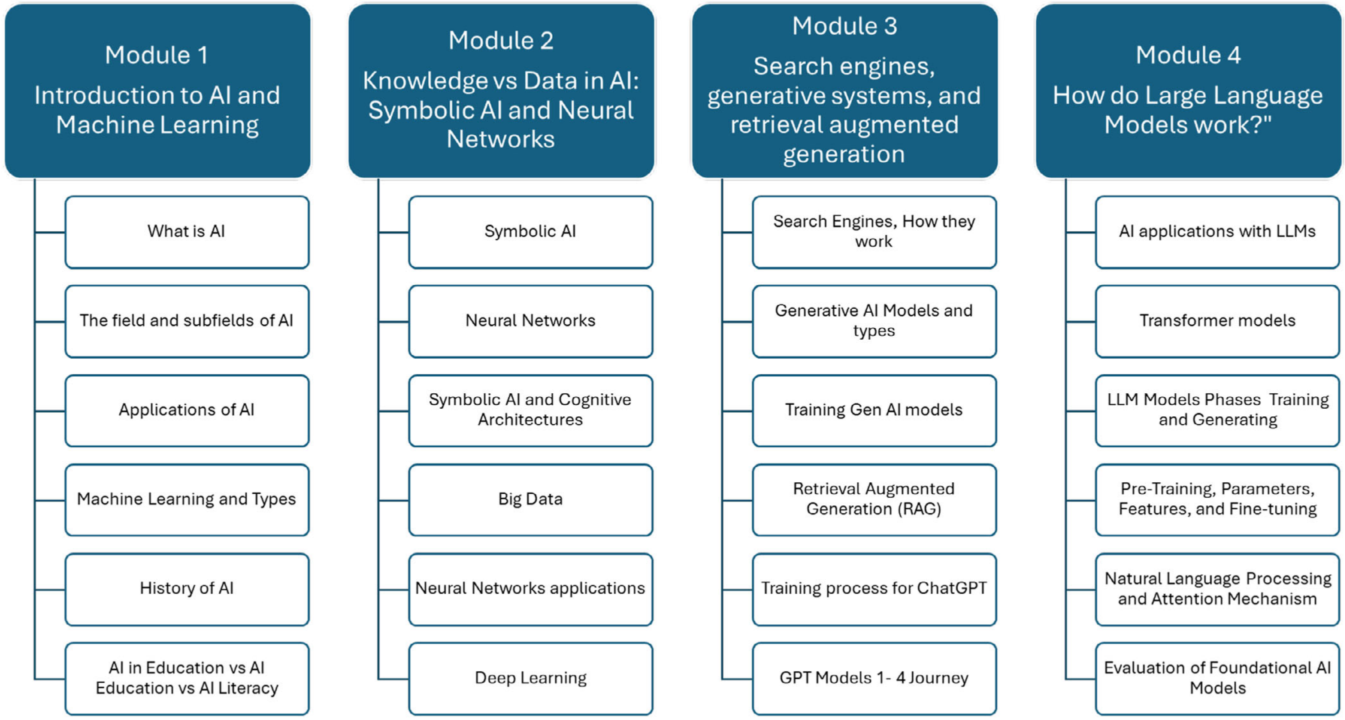

FIGURE 5 Topics covered in Modules 1–4, which map onto Pillar 1 of AI literacy.

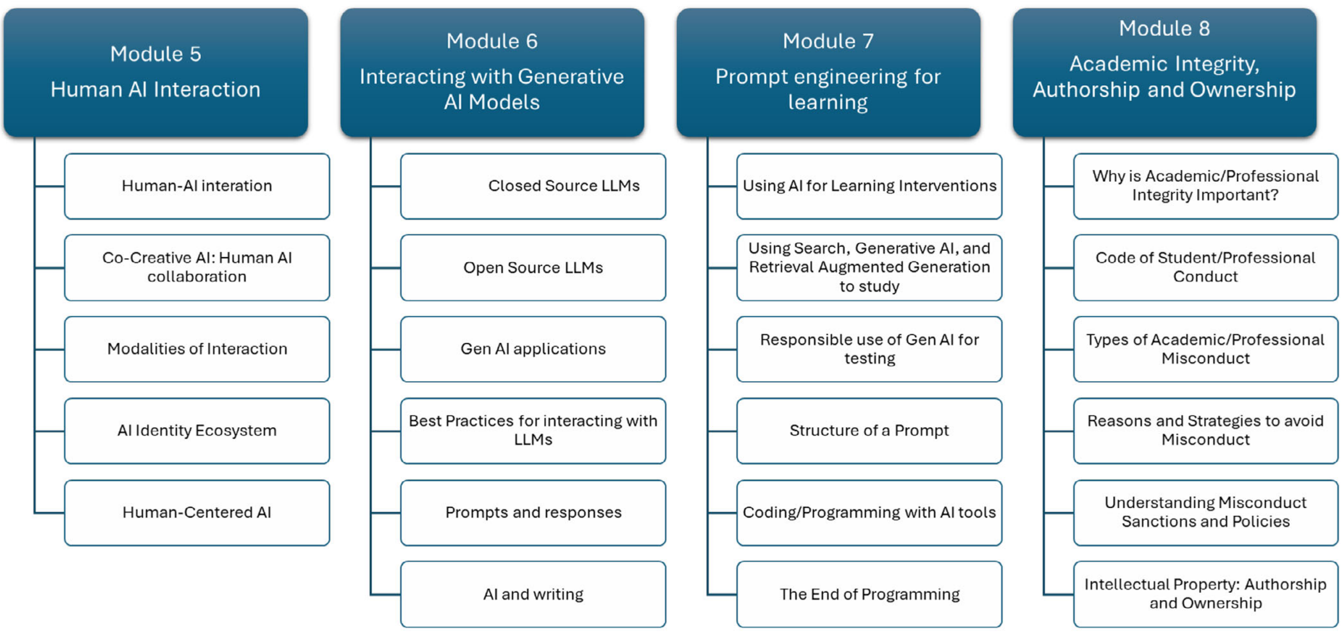

FIGURE 6 Topics covered in Modules 5–8, which map onto Pillar 2 of AI literacy.

customer service are also discussed, illustrating the pervasive impact of AI technologies. Additionally, the module examines the different types of machine learning—supervised, unsupervised, reinforcement—highlighting their unique approaches and uses (Lorberfeld 2021). Deep learning, as a subset of machine learning that uses deep neural network models with multiple layers of interconnected units to learn from large and complex datasets, is introduced. While not a separate paradigm, deep learning techniques are commonly applied within supervised, unsupervised, and reinforcement learning settings (Mienye and Swart 2023). A historical perspective is pro-

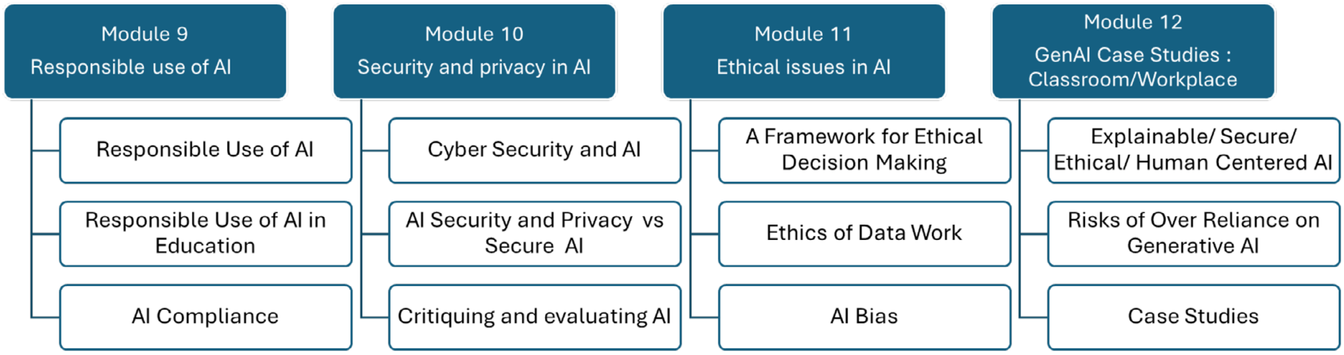

FIGURE 7 Topics covered in Modules 9–12, which map onto Pillar 3 of AI literacy.

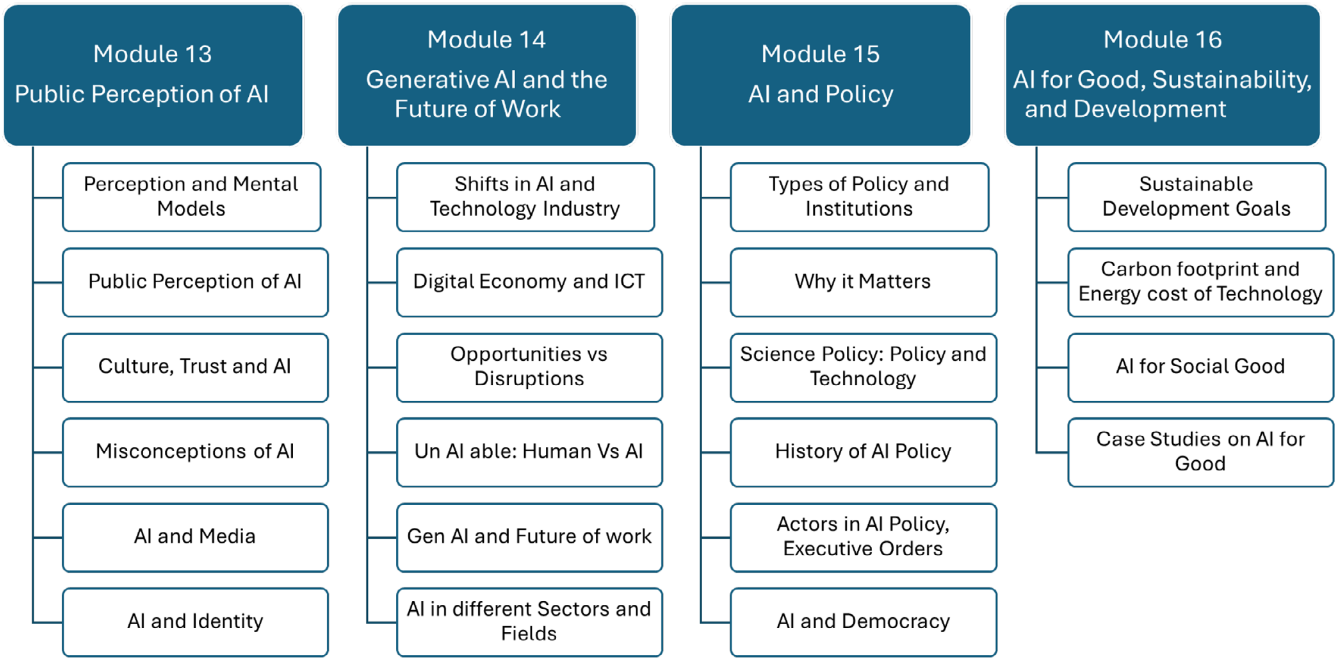

FIGURE 8 Topics covered in Modules 13–16, which map onto Pillar 4 of AI literacy.

vided, tracing AI's evolution from its inception in the 1950s to contemporary advancements and ethical concerns. Finally, the module distinguishes between AI in education (using AI to enhance learning), AI education (teaching technical AI skills), and AI literacy (broad understanding of AI principles and impacts), underscoring the importance of each in preparing a diverse and informed workforce for the AI-driven future.

Module 2: Knowledge versus data in AI: Symbolic AI and neural networks

The current AI landscape has been significantly shaped by symbolic and neural network approaches. However, current AI practices also prominently include statistical, probabilistic, and hybrid methods. Techniques such as decision trees, random forests, support vector machines, and evolutionary algorithms represent important methodologies beyond the symbolic/neural distinction and are provided as additional reading resources. In this module, the primary focus is on enabling learners to distinguish between and understand symbolic AI and neural Networks. Symbolic AI uses symbols, logic, constraints, and rules to represent knowledge, relying on structured knowledge bases and inference engines for reasoning and decision-making; this is often effective for tasks requiring clear logic (e.g., expert systems). The module further explores: cognitive architectures (incorporating symbolic AI to simulate human cognitive functions). In contrast, neural networks are a class of machine learning models composed of layers of interconnected nodes (or "neurons") that process data by learning patterns from large datasets. They are particularly effective for tasks involving perception, prediction, and pattern recognition, such as image classification, NLP, and generative modeling. Students also learn the importance of data, the 5 Vs of Big Data (Volume, Velocity, Variety, Veracity, Value), and about diminishing returns and data efficiency. They are also exposed to terminology of data infrastructure (cloud, data warehouse, and pipelines). In addition to understanding the role of big data, students will also engage with core concepts that underpin responsible machine learning practices connected to data. One key challenge in model development is to achieve the right balance between underfitting and overfitting. These practices are essential to ensure that AI systems are not only accurate but also robust, generalizable, and ethically sound when deployed in real-world settings. By examining these diverse methods of access and use of information, students gain insight into the strengths and limitations of different AI approaches and their corresponding real-world applications.

Module 3: Search engines, generative systems, and retrieval augmented generation

This module addresses the recent developments in generative AI that have led to the intersection of generative AI and information retrieval. It covers the fundamental principles and technologies behind search engines, retrieval augmented generation (RAG), and generative AI models. It explains how search engines operate through web crawling, indexing, and algorithms to quickly return relevant results. Generative AI models, including generative adversarial networks (GANs) and large language models (LLMs) like GPT-3 and GPT-4, are discussed in terms of their ability to learn from data and generate new content. The module also details the journey of GPT models from GPT-1 to GPT-4, highlighting advancements in AI capabilities and applications in NLP. The concepts of the training process for these models, involving pre-training on vast datasets and fine-tuning for specific tasks, are briefly introduced. Students learn how RAG enhances generative models by retrieving relevant information from external knowledge bases, ensuring accurate and contextually relevant responses. By examining the differences in the fundamental technology employed by web search and generative AI, students learn to critically assess the value and distinctions in their use of alternative platforms for information retrieval. By examining the differences in the fundamental technology employed by web search and generative AI, students learn to critically assess the value and distinctions in their use of alternative platforms for information retrieval.

Module 4: How do large language models work?

This module covers the intricate workings of LLMs, their applications, training processes, and the evolution of various generative models (Jain 2022). LLMs are utilized in numerous AI applications such as text generation, translation, summarization, and question-answering systems. LLM's power virtual assistants, chatbots, and content creation tools by leveraging their ability to predict and generate human-like text. Students learn about the process of training an LLM, which involves pre-training and fine-tuning. During pre-training, the model learns language patterns from vast datasets, while fine-tuning tailors the model to specific tasks using task-specific data. Transformer models are introduced, including generative pre-trained transformers (GPT) and bidirectional encoder representations from transformers (BERT), as they have revolutionized NLP by using self-attention mechanisms to handle long-range dependencies in text. Additional research readings are provided on transformers as they have become the backbone of most recent LLMs. The generating phase involves tokenizing the input text, predicting the next tokens, and sampling to produce coherent output. Pre-training involves learning from large corpora to understand language structure and context. Parameters (weights) in the model determine its capacity to capture complex patterns. Features are extracted during this phase and can be repurposed for various tasks. Fine-tuning adjusts these parameters for specific applications, enhancing performance on particular tasks. NLP with LLMs benefits greatly from attention mechanisms, which allow the model to focus on relevant parts of the input text, improving understanding and generation. This mechanism assigns different weights to different words in a sentence, enabling the model to capture context more effectively. Evaluating LLMs involves measuring their performance on benchmarks like accuracy, fluency, and relevance in tasks such as text completion, translation, and summarization. Students are briefly exposed to concepts of cross-validation, connecting back to under-fitting and over-fitting of data. Continuous evaluation helps refine these models, ensuring they meet the desired standards of accuracy and reliability. Through this module, students will gain a basic understanding of how LLMs function, their training processes, and their applications in real-world scenarios, providing a solid foundation in the principles and practices of modern AI systems.

Module 5: Human AI interaction

This module focuses on the design, evaluation, and understanding of how humans interact with AI-driven systems. Students explore how user interfaces, feedback loops, and collaborative processes are structured to facilitate effective engagement between people and AI. A key aspect is the concept of co-creative AI, where human expertise and AI capabilities converge to produce outcomes neither could achieve alone. Discussions address the AI Identity Ecosystem, emphasizing the interplay between AI development (its design and creation, including embedded values and biases) and the diverse social, cultural, and personal identities of users and consumers. Human-centered AI frameworks underscore the importance of aligning AI tools with human needs and values, ensuring user well-being, safety, and trust. The module also examines different modalities of interaction, from text-based chats and voice assistants to more immersive environments like virtual or augmented reality. Through hands-on exercises and case studies, students learn how design choices influence user experience and how to evaluate AI systems for usability, accessibility, and ethical integrity.

Module 6: Interacting with generative AI models

This module covers interacting with LLMs (LLMs), encompassing both closed-source and open-source models, their applications, best practices for interaction, and the dynamics of prompts and responses in AI-driven content generation. Closed-source LLMs, like OpenAI's GPT-4, are proprietary models maintained by organizations, typically requiring licenses or subscriptions for use, whereas open-source LLMs, such as those available on Hugging Face, are publicly accessible, encouraging collaboration and community-driven improvements. Students learn how to navigate platforms like Hugging Face. Generative AI applications span a wide range of uses, including content creation, chatbots, language translation, programming assistance, educational tools, enhanced search engines, summarization, sentiment analysis, legal and medical document analysis, creative writing, personalized recommendations, accessibility features, email assistance, game development, and fake news detection. Best practices for interacting with LLMs include asking for reasoning behind answers, looking for consistency, corroborating information, reporting harmful content, avoiding personal questions, and maintaining critical thinking. Effective prompts should be clear, provide necessary context, and ask specific questions, using natural language. In AI-driven writing, LLMs assist in generating drafts, enhancing text quality, and providing writing assistance, while creative AI can be used to generate images, sound, and video, fostering co-creative processes in various media. This module equips students to leverage LLM capabilities effectively while maintaining a critical perspective.

Module 7: Prompt engineering for learning and other use cases

This module focuses on utilizing AI to enhance higher education through tailored learning interventions and effective prompt design. It covers the use of search engines, generative AI for studying or performing tasks, emphasizing responsible use to maintain academic integrity. The module teaches the structure of a well-crafted prompt, which includes context, constraints, role modeling, step-by-step instructions, personalization, and pedagogical focus. Students learn how AI tools can assist in coding and programming by providing code suggestions, debugging support, and learning resources. They enable students to tackle complex programming tasks more efficiently and learn best practices through hands-on interaction with AI-generated code. Students learn how to leverage AI tools for coding and programming, exploring Vibe-coding and the potential shift toward high-level problem-solving with AI automation. Additionally, the module outlines seven approaches for LLMs to support learning, such as tutoring, practice questions, feedback, research assistance, writing support, language translation, and simulation. Our development of this module is tailored specifically to higher education, using examples and applications relevant for university students to ground these concepts in the student experience.

Module 8: Academic/professional integrity, authorship, and ownership

This module explores the significance of integrity in maintaining the credibility of educational/professional identity and the validity of their qualifications. It covers the Code of Student Conduct, types of academic misconduct such as plagiarism, cheating, fabrication, collusion, and deception, and the importance of avoiding misconduct to uphold personal integrity and future opportunities. The module also discusses the sanctions for misconduct and strategies to avoid it, like proper citation, time management, and understanding institutional policies. The conversation extends to intellectual property rights, copyright, exploring who owns the outputs generated by AI tools, and clarifying issues around co-creation. Connecting to AI literacy, understanding, and upholding academic integrity is crucial as AI tools become integrated into educational practices, ensuring that the use of AI in learning and assessments is conducted ethically and responsibly, preserving the value of academic work in the age of AI.

Module 9: Responsible use of AI

This module is a discussion of the ethical and responsible integration of AI in education through socio-technical AI frameworks that emphasize responsible AI, explainable AI (XAI) and trustworthy AI practices, human-centered AI (HCAI), Ethical and equitable AI, and continuous monitoring for compliance. It introduces the concepts of AI compliance and quality standards, ensuring that AI systems adhere to ethical guidelines, regulatory requirements, and best practices for secure, fair, and transparent operations. It addresses the importance of academic integrity and the risks associated with over-reliance on generative AI, such as algorithmic bias, impaired creativity, and reduced critical thinking. The module also explores AI compliance, ensuring adherence to ethical standards and regulations, and presents case studies highlighting responsible and irresponsible uses of AI in educational settings. These case studies provide practical examples to illustrate the principles of responsible AI use, helping students understand the complexities and ethical considerations involved in leveraging AI technologies in their academic and professional lives.

Module 10: Security and privacy in AI

This module addresses the critical aspects of security and privacy in AI systems, emphasizing how AI can both safeguard and challenge data protection. Students explore the intersection of AI and cybersecurity, learning how machine learning can detect threats more efficiently while also presenting new vulnerabilities that must be carefully managed. Ethical considerations feature prominently, as AI-driven decisions can raise questions of bias, transparency, and accountability. The module highlights the concept of "secure AI," which refers to AI architectures designed with robust defense mechanisms from inception, including data protection measures and user-consent protocols. Students also learn about various methods for critically evaluating AI outputs, assessing how secure and ethically sound they are within educational, corporate, and societal contexts. By examining case studies, learners gain a practical understanding of balancing innovation and caution in building and deploying AI systems.

Module 11: Ethical issues in AI

This module explores the ethical complexities surrounding AI. Students examine how AI-driven systems can inadvertently propagate biases, compromise privacy, or manipulate public opinion. They explore frameworks for ethical decision-making and critical thinking, addressing principles such as beneficence, non-maleficence, autonomy, and justice in AI contexts. The roles of data ethics and fairness are highlighted, including how biased datasets and poorly tested algorithms can lead to inequitable outcomes. Students consider real-world incidents that showcase issues such as algorithmic discrimination, invasive data collection, or ethically questionable predictive modeling. This curriculum emphasizes that ethical responsibility extends to every stage of AI development—from data collection and model design to deployment, monitoring, and continuous improvement. By the end of this module, learners will have gained a nuanced perspective on how ethical considerations shape AI's societal impact and the essential interventions that can ensure AI's benefits are equitably distributed.

Module 12: Case studies GenAI: Classroom/workplace

This module uses real-world scenarios to illustrate how generative AI tools are integrated into educational and professional environments, examining both the advantages and pitfalls. Students review case studies where teachers/students use AI-generated quizzes to personalize learning, leading to improved engagement but also raising questions about dependency on automated content. In workplace contexts, AI-driven content generation can accelerate tasks like report writing or data analysis, yet challenges arise around maintaining human oversight and verifying output accuracy. Additional examples might include AI-assisted creative brainstorming in design or AI-aided problem-solving in software engineering. Through in-depth discussion and critical reflection, learners identify how to balance AI efficiency with ethical considerations, ensuring that generative AI tools complement rather than replace human expertise. This module highlights best practices for implementing GenAI responsibly, providing actionable guidelines for professionals and educators alike. Students apply learnings from previous subtopics under Pillar 3.

Module 13: Public perception of AI

This module explores the various facets of public perception of AI, focusing on how different factors shape understanding and attitudes toward AI technologies. Students discuss how individuals and society conceptualize AI, influenced by mental models formed through education, media, and personal experiences. Understanding these mental models is crucial for addressing misconceptions and fostering informed perspectives on AI (Woodruff et al. 2024). Public attitudes toward AI are shaped by a mix of optimism and fear. Surveys and studies, such as those conducted by Pew Research, reveal diverse opinions about AI's impact on jobs, privacy, and societal norms (Faverio and Tyson 2023). These perceptions are often influenced by media portrayals and personal interactions with AI technologies. The media plays a pivotal role in shaping public perception of AI. Films, news articles, and social media can either inform or misinform the public. Analyzing media representations helps understand how these narratives influence societal attitudes and fears about AI. Cultural contexts also significantly influence trust in AI. In some cultures, there is a higher acceptance and trust in technology, while others may be more skeptical. Building trust involves ensuring transparency, reliability, and ethical use of AI, which can vary widely across different cultural settings. Common misconceptions include overestimating AI's capabilities or fearing that AI will completely replace human jobs. Clarifying these misunderstandings is essential for realistic expectations and responsible integration of AI into various sectors. The module concludes by studying how AI technologies can impact personal and social identity, affecting how individuals perceive themselves and their roles in a technologically advanced society. This includes discussions on digital identity, privacy, and the implications of AI in social dynamics.

Module 14: Generative AI and the future of work

This module explores the transformative impact of generative AI on the future of work, covering shifts in the AI and technology industry, the digital economy, opportunities versus disruptions, and the role of human versus AI capabilities across various sectors (Verdegem 2021). Generative AI is significantly altering the technology landscape, especially in software development. Tools like GitHub Copilot enhance productivity by enabling developers to quickly adapt to new programming languages, provided they have foundational skills like data structures and algorithms. As generative AI continues to evolve, its influence extends to the entire software lifecycle, necessitating continuous adaptation and upskilling in durable skills. The integration of AI into the digital economy and Information and Communication Technologies (ICT) is creating new economic opportunities and transforming business processes. AI-driven automation and data analytics are reshaping industries by optimizing operations, enhancing decision-making, and creating new business models. While generative AI opens up numerous opportunities for innovation and efficiency, it also brings disruptions, particularly in job roles that rely on semi-perishable and perishable skills. There is a disproportionate impact on different groups, with some job roles becoming obsolete while new roles emerge, emphasizing the need for continuous learning and adaptation. Despite advancements in AI, certain tasks remain "un-AI-able," requiring human intuition, creativity, and problem-solving capabilities. Data scientists, for instance, continually face new scenarios and solve novel problems that AI cannot handle due to its lack of intuition and adaptability to unprecedented challenges. The future of work with generative AI involves a symbiotic relationship where AI tools augment human capabilities. Generative AI can automate routine tasks, freeing up humans to focus on complex and creative aspects of their work. This collaboration enhances productivity and innovation across various fields. AI's impact varies across different sectors, including healthcare, finance, education, and entertainment.

Module 15: AI and policy, case study of accessibility

In this module, students explore the policy landscape that governs AI's ethical and equitable use. The discussion begins with how economic, social, and technological policies operate at local, national, and global levels to address the rapid advancements in AI. Tracing the history of AI policy in America reveals how government directives, executive orders, and global frameworks seek to balance innovation with ethical standards. Key policy actors include regulatory agencies, technology companies, academic institutions, and civil society organizations. Students examine AI and Democracy, debating how policy can maintain transparency and accountability in AI decision-making. The module concludes with a case study of AI and Accessibility, illustrating how robust policies can ensure that people with disabilities or other underrepresented groups benefit from AI technologies. By applying the AI identity framework, learners see how inclusion-oriented policy initiatives can enhance or hinder equitable outcomes and why comprehensive governance measures are critical to preventing AI-driven disparities.

Module 16: AI for good, sustainability, and development

This module explores how AI can contribute positively to sustainability and development goals, focusing on its potential for social good and environmental impact. AI plays a crucial role in advancing the United Nations Sustainable Development Goals (SDGs) by addressing global challenges such as poverty, hunger, health, education, and climate change. AI-driven solutions can enhance efficiency, provide innovative approaches, and offer scalable solutions to meet these goals. While AI offers many benefits, it also poses challenges such as high carbon footprints and significant energy consumption. This section addresses the environmental impact of AI technologies, emphasizing the need for sustainable practices in AI development and deployment to minimize energy costs and carbon emissions. AI applications for social good include projects that address societal challenges, such as improving healthcare outcomes, enhancing educational access, supporting disaster response, and promoting social justice. AI can analyze large datasets to identify patterns, predict outcomes, and provide insights that drive positive social change. Real-world examples illustrate the transformative power of AI in promoting social good. Case studies include AI systems that predict natural disasters, improve agricultural yields, optimize resource management, and provide personalized healthcare solutions. These examples demonstrate the practical applications of AI in creating a more equitable and sustainable world.

LEARNING AND ASSESSMENT

Learning and assessment are inherently interwoven, underscoring the importance of deliberate assessment design when crafting the pedagogical foundations of any learning environment. In the context of AI literacy, assessments serve as crucial indicators of students' understanding of AI concepts and their capacity to apply these concepts in multifaceted scenarios. Beyond testing for technical proficiency, well-rounded assessment strategies also capture ethical considerations, critical engagement with AI, and the ability to leverage AI in solving real-world problems (Almatrafi, Johri, and Lee 2024; Kong, Cheung, and Tsang 2024). Given the interdisciplinary character of AI, these assessments often integrate hands-on technical tasks with scenario-based challenges, prompting learners to grapple with socio-technical complexities. Alongside the development of AI curricula, there has been a growing call for empirical and interventional research designs to examine the effectiveness of AI literacy interventions, motivated by the current predominance of exploratory studies in the field (Ng et al. 2021b; Su, Ng, and Chu 2023). In the following sections, we will map the AI literacy assessment landscape and propose a comprehensive approach to defining learning outcomes for AI literacy with an instantiation of this course.

AI literacy assessment

Recent years have witnessed a notable surge in both conceptualizing and measuring AI literacy across varied settings and populations. Ongoing efforts to devise and validate AI literacy assessment tools remain essential, as they provide researchers and educators with reliable measures of AI-related competencies (Carolus et al. 2023; Laupichler et al. 2023). Exploratory analyses of these tools have already provided insights into the latent dimensions of AI competence, paving the way for more robust methodologies that assess not only knowledge but also ethical judgment (Knoth et al. 2024). This transition toward empirical rigor reflects a broadening perspective on AI literacy, one that aligns with rapid technological developments and aims to establish comprehensive educational frameworks. A recent trend involves self-report instruments that gauge individuals' perceptions of their AI-related knowledge, skills, and attitudes (Laupichler et al. 2022; Lintner 2024). Survey-based scales—often covering dimensions such as awareness, practical usage, and ethical considerations—are straightforward to administer and interpret (Wang, Rau, and Yuan 2023). These scales are often focused on particular populations and learning outcomes, for instance, the scale for the assessment of non-experts' AI literacy (SNAIL) targets individuals lacking formal AI training and emphasizes technical understanding, critical appraisal, and practical application (Laupichler et al. 2023). We have seen a rise in domain-specific AI literacy assessment tools. The medical artificial intelligence readiness scale for medical students (MAIRS-MS) measures cognition, ability, vision, and ethics related to AI in clinical contexts (Karaca, Çalışkan, and Demir 2021). Similarly, in technology education, (Stolpe and Hallström 2024) leverages foundational guidelines such as AI4K12 and UNESCO's domain mapping for AI to produce teaching and evaluation strategies aligned with specific grade levels and subject areas.

While these self-assessment approaches capture important subjective dimensions, some researchers advocate for more comprehensive frameworks that integrate cognitive, behavioral, and attitudinal aspects (Knoth et al. 2024). Systematic reviews of various instruments underscore a growing consensus on the need for multifaceted instruments that combine knowledge-based assessment with self-perceived competence (Lintner 2024; Williams 2023). These broader models adopt the Attitude, Behavior, and Cognition (ABC) framework, positing that robust AI literacy involves not only theoretical understanding, such as algorithmic functions, but also ethical standpoints and a willingness to use, develop, or critically evaluate AI systems (Pinski and Benlian 2023; Weber, Pinski, and Baum 2023). For example, the meta AI literacy scale (MAILS) expands beyond cognitive competencies to include self-efficacy components (e.g., AI problem-solving and learning efficacy) as well as meta-competencies like AI persuasion and emotion-regulation literacies (Carolus et al. 2023). Supporting this view, knowledge-based tests, self-report surveys, and empowerment measures are being used in combination to capture both the practical and affective outcomes of an AI literacy program for university learners (Kong, Cheung, and Zhang 2021). As AI technologies permeate everyday life, a comprehensive assessment must also address ethical implications, societal impacts, and individual readiness, encompassing not only knowledge and skills but also attitudes toward AI technologies (ATAI) (Grassini 2023; Sindermann et al. 2021; Suh and Ahn 2022). Researchers have started to integrate these components into frameworks that reflect both cognitive and affective dimensions, as seen in newer instruments aligning with holistic conceptualizations of AI literacy (Ng et al. 2021a; Yuan, Tsai, and Chen 2024). Such mixed-method designs illuminate discrepancies between perceived and demonstrated competencies, offering a more nuanced view of students' readiness for AI-driven environments.

Across various conceptualizations of AI literacy, course design is often shaped by whether the associated measurement instruments are subjective or objective. Subjective assessments rely on self-reported, interpretive data, which can provide contextually rich insights but are susceptible to bias and inconsistency. In contrast, objective assessments use standardized tasks and criteria, offering more consistent results, though often within a narrower scope.

Building on this distinction, recent AI literacy assessment tools from the past year can be clustered based on the primary competency they measure: knowledge/cognition, skills, behavior/self-efficacy, values/attitudes, AI mental models, and perceptions of AI. These clusters reflect a continuum spanning both technical and socio-technical competencies.

In this paper, we align these competency domains with the four pillars of the AI literacy framework (see Figure 9), specifically:

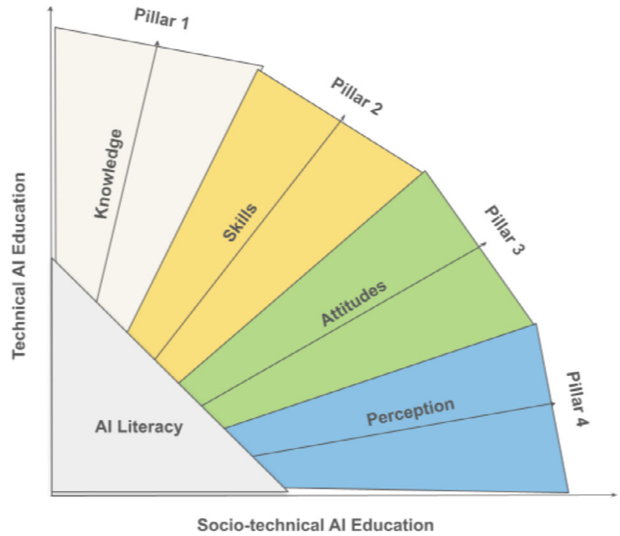

FIGURE 9 AI literacy competencies mapped across the four pillars: knowledge, skill, attitude/mental models, and perception/awareness.

1. Understand the scope and technical dimensions of AI maps to **knowledge**,
2. Learn how to interact with (generative) AI technologies maps to **skills**,
3. Apply principles of critical, ethical, and responsible AI usage maps to **attitudes**, and
4. Analyze implications of AI on society maps to **perception**.

These competencies are interrelated and overlap exists across some pillars, the alignment below highlights the clustering decision based on the learning outcomes and assessments emphasized within each pillar

Pillar 1 aligns with the assessment focus of traditional AI education, which emphasizes evaluating students' understanding of the technical and mathematical foundations needed to build, assess, and apply AI models. In the context of AI literacy—where the goal is not technical mastery but conceptual comprehension—this is translated into assessments that test students' ability to recall, define, and contextualize AI concepts. These are typically **knowledge-based** assessments aimed at vocabulary building and foundational understanding.

Pillar 2 corresponds to the focus of many public AI literacy frameworks and emerging generative AI curricula, where the goal is to enable learners to confidently interact with AI tools in everyday contexts. Assessments here often center on self-efficacy and functional **skills—evaluating** whether learners can use AI tools appropriately and effectively. This includes the ability to craft meaningful prompts, understand the dynamics of human-AI interaction, and co-create or augment their work using AI systems.

Pillar 3 emphasizes learners' capacity to reflect critically on their own use of AI and to examine the broader **human behaviors, attitudes, and mental models** associated with it. The assessment focus shifts toward introspection—evaluating attitudes, ethical reasoning, and the ability to critique AI systems and their applications. Learners are encouraged to develop a responsible mindset and to consider the implications of their personal/individual choices in using AI technologies.

Pillar 4 emphasizes the societal and systemic implications of AI technologies. Discussions in these modules engage learners in understanding how AI development is influenced by—and in turn influences—social, cultural, economic, and political systems. Assessment in this domain focuses on **learners' perceptions and civic awareness,** encouraging them to analyze narratives around AI and reflect on its impact in areas such as sustainability, labor, policy, and equity.

This approach offers a more comprehensive and inclusive framework for identifying which competencies are being assessed, by whom, and in which context. Moving forward, cross-validation of existing scales, longitudinal studies to track the evolution of AI literacy, and investigations into the interplay between the four AI literacy pillars and broader AI education efforts hold promise for advancing both research and practice. By broadening the scope of assessments, educators and policymakers can better equip learners with the comprehensive suite of competencies required to navigate an AI-infused world.

Mapping learning outcomes across the four pillars according to Bloom's taxonomy

Another perspective on assessment is the alignment of learning outcomes in AI literacy to Bloom's revised taxonomy. Tables 1 and 2 present a structured overview of learning outcomes for AI literacy for each level in Bloom's revised taxonomy to demonstrate how competencies (knowledge, skill, attitudes, perception) can progress from "remembering" to advanced "creating." Each of the four columns highlights one of the four pillars of AI literacy, ranging from technical scope to generative AI usage, ethical responsibility, and broader societal implications. Within each level of Bloom's taxonomy, learners engage with tasks reflecting increasing cognitive complexity, such as recalling core AI concepts, critiquing existing systems, and ultimately proposing innovative AI solutions. Items *Italicized* in the table represent objectives that extend beyond our immediate scope of AI literacy but remain integral to a comprehensive AI education. This structure underscores the multifaceted nature of AI learning, emphasizing the importance of both deep technical understanding and responsible, context-sensitive application.

Designing the student learning experience for AI literacy

In an era where educational content is abundant and often AI-generated, developing students' critical thinking skills and their ability to articulate, collaborate, and discuss these concepts with others becomes even more important. An active learning approach, centered around collaboration, critical thinking, discussions, and reflection, is essential (Kim et al. 2021). Students were assessed and evaluated as shown in the Bloom's taxonomy (Krathwohl 2002) mapping in Figure 10. We describe the various learning experiences we employed to show the diversity of ways in which students engaged with the learning materials. When designing the student experience in a socio-technical AI literacy course, it is important to combine learning experiences and assessments that involve writing, reflecting, recalling, and applying technical skills. Our AI literacy course utilized active learning techniques to encourage students to learn collaboratively and in the presence of the instructor, whether in virtual, physical, or hybrid formats (Latulipe et al. 2022). We recognize that the modality of instruction should adapt depending on the discipline, course level, and audience (Tadimalla and Maher 2024a).

- **AI dictionary** Students create a personalized dictionary of AI terms and concepts encountered throughout the course. The entries are evaluated based on completeness, accuracy, and depth of understanding. Existing literature suggests that creating such personalized learning tools can enhance retention and comprehension
- **Weekly and subtopic reflections** Weekly reflections require students to write summaries of what they learn that week and how they are feeling in the course, and personal insights on the topics they want to learn more about and why. This was done in Discussion boards, in class discussions within their small groups, also personal reflection assignments. Reflections are assessed based on depth of thought, connection to course material, and critical analysis. Reflective writing has been shown to improve critical thinking and learning outcomes.
- **Weekly labs** Practical labs where students apply AI concepts through hands-on activities, such as coding exercises with AI or experiments with media creation with AI. Evaluation is based on accuracy, completion, and the ability to apply theoretical concepts in

TABLE 1 Learning outcomes focusing on the Bloom's taxonomy levels of remembering, understanding, and applying, organized across four pillars of AI literacy.

Bloom's level	(1) Understand the scope and technical dimensions of AI	(2) Learn how to interact with (generative) AI technologies	(3) Apply principles of critical, ethical, and responsible AI usage	(4) Analyze implications of AI on society
Remembering	- Identify basic AI terms (machine learning, symbolic AI, neural network AI) and historical developments (Turing, Perceptron). - Recall the differences between search-based vs. generative approaches.- List core concepts of how neural networks and transformers work. - Memorize key terminology (prompt, token, fine-tuning) relevant to generative models.	- Recognize examples of AI-human interaction (chatbots, voice assistants). - Name ethical guidelines for academic integrity in AI usage.	- List typical ethical dilemmas (data bias, privacy leaks, accountability).- Identify relevant security concerns in AI (e.g., adversarial attacks). - Recall major regulations or frameworks (e.g., EU AI Act, AI FAccT landscape, etc).	- Recall basic facts about AI's role in everyday life (recommendation systems, automation). - Recognize how AI policy might address accessibility issues.- List examples of AI projects for social good or sustainability.
Understanding	- Explain how machine learning models differ from symbolic AI in terms of data vs. rule-based approaches. - Describe how retrieval-augmented generation (RAG) integrates external data into generative models. - Interpret the architecture of neural nets and large language models.	- Describe how generative AI models produce text or images from large training sets. - Summarize human–AI interaction principles (e.g., user-centered design, transparency). - Clarify intellectual property guidelines for generated content.	- Discuss why responsible AI is crucial (impact on trust, fairness, inclusivity). - Explain privacy and security fundamentals (data protection, encryption) in AI. - Interpret how ethical concerns manifest in classroom or workplace case studies.	- Interpret how public perception of AI influences policy decisions. - Outline possible shifts in the labor market due to generative AI's automation potential. - Discuss how AI can advance sustainability goals (environmental monitoring, resource optimization).
Applying	*- Demonstrate machine learning concepts by coding a small model or analyzing AI-driven search results. - Use symbolic vs. neural network strategies on sample datasets to see performance differences. - Experiment with basic RAG setups to retrieve and synthesize information.*	- Employ generative AI tools (ChatGPT, image generators) for creative or professional tasks (e.g., drafting reports, image creation, audio generation). - Refine prompts or system parameters for better outputs. - Apply best practices for authorship and ownership in AI-assisted work.	- Draft responsible AI guidelines in a simulated scenario (e.g., a class using face recognition). - Address security/privacy vulnerabilities in a small AI prototype. - Practice analyzing real or hypothetical ethical breaches and propose short-term fixes.	*- Investigate how AI automation might affect a chosen sector (healthcare, finance, etc.). - Map out policies that enhance accessibility for AI tools (e.g., inclusive design features). - Examine how AI for Good initiatives tackle sustainability or humanitarian goals.*

Note: Items *Italicized* in the table represent objectives that extend beyond our immediate scope of AI literacy but remain integral to a comprehensive AI education.

practical scenarios. Hands-on labs are effective for deepening understanding and improving technical skills.

- **Case studies** Case Studies are integrated into the course to help students connect theoretical AI concepts with real-world applications. Each pillar includes at least 1 case study in its modules that presents a scenario highlighting a specific challenge or ethical dilemma. Students are asked to analyze these scenarios, propose potential solutions or interventions, and reflect on broader socio-technical implications. Assessment criteria include depth of analysis, creativity in problem-solving, and the ability to articulate and justify ethical stances. Case studies often culminate in group discussions or presentations, fostering collaboration, critical thinking, and an appreciation for diverse perspectives.
- **Midterm** For non-majors, the midterm involves taking an assignment they previously completed for another class, using AI tools to redo it, and reflecting on the outcome. They critique the tools' ability to perform the task and consider how to integrate principles of responsible

TABLE 2 Learning outcomes focusing on the Bloom's taxonomy levels of analyzing, evaluating, and creating, organized across four pillars of AI literacy.

Bloom's level	(1) Understand the scope and technical dimensions of AI	(2) Learn how to interact with (generative) AI technologies	(3) Apply principles of critical, ethical, and responsible AI usage	(4) Analyze implications of AI on society
Analyzing	*- Compare performance of different neural architectures (RNNs, transformers) or symbolic methods on complex tasks.- Investigate how RAG vs. purely generative models handle varied data sets.- Break down the trade-offs of data-driven vs. knowledge-driven AI*	- Analyze strengths, weaknesses, and biases of specific generative models.- Identify improvements in human–AI interaction interfaces.- Examine how academic integrity can be compromised by advanced AI generation.	- Dissect ethical issues, exploring root causes (biased data, oversight lapses).- Evaluate security threats like adversarial inputs or data poisoning for educational/workplace AI.- Explore multi-stakeholder perspectives in real-case studies.	- Assess the cultural and socio-economic factors influencing AI adoption (e.g., acceptance, digital divide).- Critique different policy approaches (European vs. US standards, for example).- Analyze success factors or drawbacks in AI for Good projects.
Evaluating	- Appraise which AI method (symbolic vs. neural network, search vs. generative) is most efficient or ethical for a given problem.- Justify algorithmic choices using metrics (accuracy, speed, interpretability).- Critique the design of large language models (scalability, resource usage).	- Evaluate generative AI outputs for correctness, originality, and ethical implications (misinformation, bias).- Judge the usability of AI interfaces from a human-centered design standpoint.- Rate the academic or professional integrity of AI-generated work.	- Weigh the pros and cons of implementing an AI-driven system in a classroom or workplace (equity vs. efficiency).- Critically review proposed security/privacy regulations for AI.- Offer reasoned critiques on an organization's ethical AI code of conduct.	- Judge the viability and ethical ramifications of future scenarios (automation, data-driven governance).- Evaluate policy proposals addressing AI accessibility and fairness.- Examine whether certain AI for Good endeavors truly meet sustainability targets.
Creating	*- Design a novel AI solution that merges/distinguishes symbolic and neural network approaches, or integrates RAG into a new domain.- Review and propose advanced architectures for neural networks or Transformers to tackle emerging problems.- Develop prototypes bridging classic ML and generative AI*	*- Build a custom generative AI application or extension (e.g., domain-specific fine-tuned model).- Envision new interaction paradigms for human–AI collaboration (voice-based, AR/VR).- Draft guidelines or tools ensuring appropriate authorship and ownership.*	*- Formulate detailed ethical guidelines and privacy safeguards for AI in education or work settings.- Construct a policy framework that addresses identified vulnerabilities, ensuring responsible AI practices.- Propose an industry-based approach to ongoing AI ethics audits.*	- Propose innovative policy models that integrate AI-driven accessibility solutions at scale.- Plan a forward-looking "AI for Good" initiative/project focusing on sustainability or development.- Envision future job structures or social programs adaptable to AI-induced change.

Note: Items *Italicized* in the table represent objectives that extend beyond our immediate scope of AI literacy but remain integral to a comprehensive AI education.

use. Evaluations are based on the quality of the reflection, the critique of the AI tools, and the understanding of responsible AI use. Such assignments foster practical understanding and critical evaluation skills

- **Quizzes** Regular short quizzes to assess ongoing understanding of the material in the class. These Quizzes are often auto-graded for quick feedback. Frequent quizzes can enhance learning and retention by providing regular feedback.
- **Project/paper** The project for this course is selected based on the discipline and course level.
  - ***Students who are not CS majors*** had the following options to (1) Read Case studies provided on AI usage and create their hypothetical case study and critique and reflect on the case study, (2) Write an essay after reading the paper "AI and identity" (Tadimalla and Maher 2024b), (3) depending on their status/year in the program the students can also opt to do a service learning project that involves teaching AI literacy concepts.
  - ***For students who are CS majors***, The projects involve (1) reviewing case studies provided on AI usage and creating their hypothetical case study and critiquing and reflecting on the case study, (2) developing an application integrating a LLM model, and (3) submitting a literature review after reading the paper "AI and identity." Students have to identify one label in each of the layers of the AI ecosystem and create an

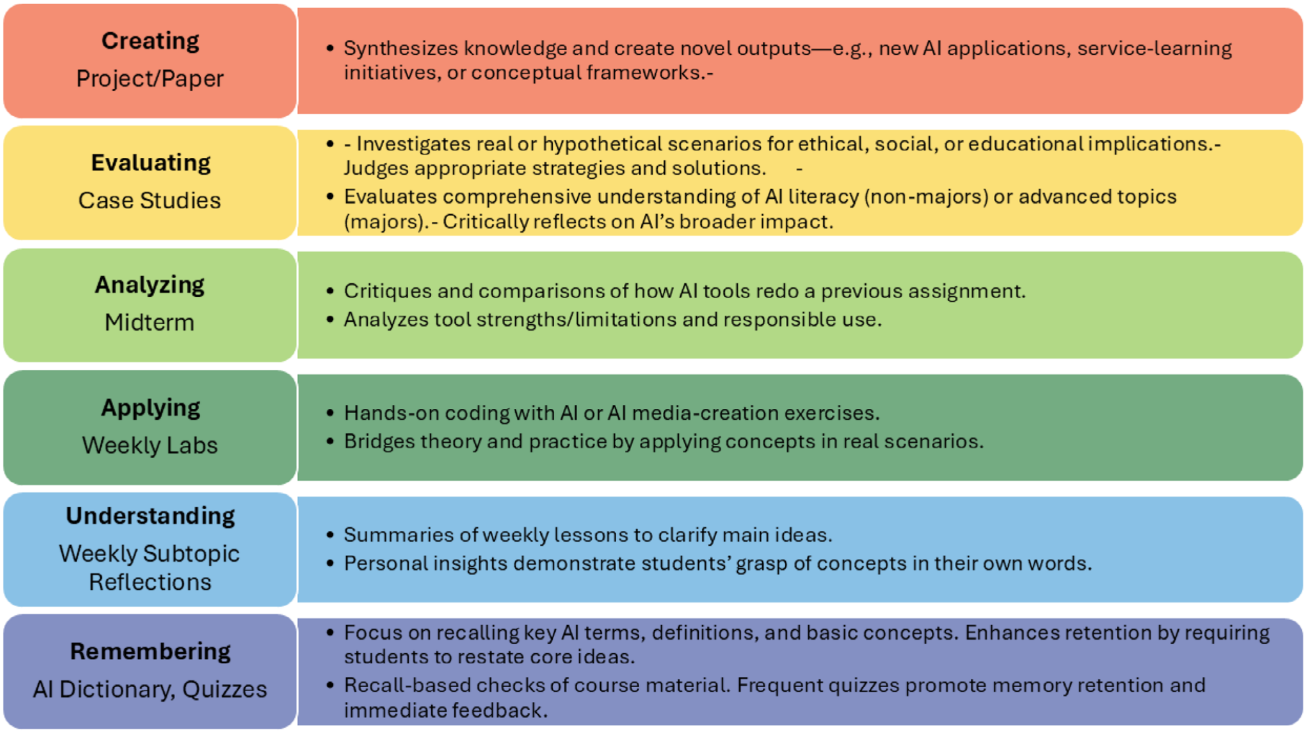

FIGURE 10 Mapping AI literacy course objectives, assessment, and evaluations across Bloom's taxonomy.

AI literacy resource to teach that specific combination or submit an analysis/position paper to address that specific combination. Projects are evaluated based on problem definition, methodology, execution, and presentation. Projects, especially when collaborative, can promote deep learning and the application of knowledge

- **Exam** for non-major students, the final exam is an AI literacy self-assessment (Carolus et al. 2023; Ng et al. 2024). For students who are CS majors, they have the option to take a final exam along with the AI literacy assessment to receive extra credit. The exam is a written exam that involves selecting 5 questions out of 16, where each question corresponds to one of the modules taught.

These examples of learning experiences encourage students to engage in a broad spectrum of socio-technical knowledge acquisition, from the development of AI technical skills to a critical understanding of responsible AI. These examples are not comprehensive and will continue with the wider adoption of AI literacy courses.

CONCLUSION

This paper emphasizes the importance of a socio-technical AI literacy course as the foundational or introductory course for all students, as the pathway to various roles as AI and/or AI literate professionals. This sociotechnical course framework approach ensures that students not only acquire technical skills but also develop an understanding of the ethical, societal, and future implications of AI, preparing them for responsible and informed participation in an AI-enabled workforce. The paper describes the relationships and distinctions among AI in education, AI education, and AI literacy. With a focus on AI literacy, the paper argues for a four-pillar approach that includes "understanding scope and technical dimensions of AI; learn how to interact with (generative) AI technologies; apply principles of critical, ethical, and responsible AI usage; and analyze implications of AI on society." For each pillar, the paper presents the scope of content for course modules, along with frameworks for assessing AI literacy and learning experiences. The adoption of AI literacy as a core component of education aims to broaden participation in AI by providing a pathway for all to be part of the AI workforce and/or the AI-enabled workforce.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict.

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