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An exploratory review on conceptualizing generative artificial intelligence literacy

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ABSTRACT

Generative artificial intelligence (AI) has rapidly evolved, demanding new forms of literacy that go beyond traditional AI concepts. However, current definitions of generative AI literacy often overlook its unique challenges, including prompt engineering, critical evaluation of AI-generated outputs, and complex ethical considerations. This study addresses these gaps through an exploratory review of 20 peer-reviewed articles. These articles were identified using systematic searches across major academic databases and selected based on predefined inclusion criteria. The analysis reveals conceptual limitations in existing frameworks, particularly their lack of structure and their generalization of AI literacy. To overcome these issues, we propose a new competency framework adapted from Bloom's taxonomy. The framework integrates three essential dimensions: technical proficiency, ethical responsibility, and societal awareness. It is organized into five progressive cognitive stages: understand, apply, analyze, evaluate, and create. This framework clarifies the distinct demands of generative AI literacy and can be implemented to guide curriculum design, professional training, and the development of generative AI literacy across sectors.

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1. INTRODUCTION

Artificial intelligence (AI) has undergone a remarkable evolution since its inception, transitioning from basic rule-based systems to the sophisticated generative models we see today. Early AI systems, developed since the mid-20th century, were largely deterministic, relying on predefined rules and logic [1], [2]. However, as computational power increased and data became more abundant, AI evolved into machine learning, enabling systems to learn patterns from data rather than being explicitly programmed. This shift paved the way for even more advanced techniques, culminating in the development of generative AI.

Generative AI represents a significant leap forward in the capabilities of AI. Unlike traditional AI systems that classify or predict outcomes, generative AI models are designed to create new content, whether it be text, images, audio, or video, that mimics human creativity [3], [4]. Tools like generative adversarial networks (GANs), diffusion models, and large language models (LLMs) such as generative pre-trained transformer (GPT) have revolutionized industries ranging from entertainment to healthcare [5], [6]. For instance, GANs have been used to generate photorealistic images for video games and virtual environments, while diffusion models have enabled advancements in image synthesis and editing [7].

In education, generative AI is being leveraged to create personalized learning materials and automate administrative tasks [1], [8], [9]. As these powerful tools become increasingly accessible to the

general public, a new form of digital literacy has become necessary. This emerging literacy goes beyond basic understanding of computers or traditional AI [10]. Instead, it focuses specifically on the unique capabilities, limitations, and implications of generative AI technologies. This growing need for specialized literacy reflects the distinctive ways in which humans must now interact with systems capable of generating human-like content.

Despite its transformative potential, there remains a notable lack of clarity around what it means to be literate in the context of generative AI. While broader frameworks of AI literacy have been explored in academic literature, generative AI literacy presents unique conceptual and ethical challenges that are not fully addressed in existing definitions [11], [12]. For instance, Hagendorff [13] highlights the importance of skills such as crafting effective prompts, iterating problem-solving processes, and critically evaluating AI-generated outputs for generative AI.

Prompt engineering, in particular, requires users to iteratively refine inputs to guide generative AI toward desired outcomes, blending technical knowledge with creative problem-solving. Similarly, the ability to critically assess AI-generated content is essential for distinguishing between authentic and manipulated information. However, these insights represent only one perspective in an ongoing debate, underscoring the need for a clear and comprehensive conceptual framework that defines the core competencies of generative AI literacy.

The lack of clarity highlights significant gaps in existing conceptualizations of generative AI literacy, posing challenges for educators, researchers, and practitioners. Addressing these gaps requires a structured framework that captures the unique demands of interacting with generative AI technologies. Without a shared understanding of what generative AI literacy entails, educators may struggle to design relevant curricula [10], [14], researchers might lack standardized metrics to assess literacy, and organizations probably encounter challenges in setting employee competency benchmarks.

This gap also creates tangible risks because students may graduate without the essential skills needed for modern workplaces [15], [16], harmful misinformation generated by AI may spread unchecked due to inadequate critical evaluation skills [17], and inequitable access to generative AI literacy could widen existing digital divides [18]. Moreover, individuals without proper generative AI literacy may be vulnerable to manipulation through deepfakes and synthetic media [19], potentially undermining trust in digital information broadly. Traditional AI literacy frameworks, which prioritize foundational concepts such as algorithms and data structures [20], are insufficient for addressing these risks. While these elements remain relevant, they do not fully address the unique demands of generative AI [21], [22], which requires users to engage in creative problem solving, iterative experimentation, and nuanced ethical reasoning that considers the implications of AI generated content.

Given these challenges, this study seeks to conceptualize generative AI literacy by critically examining existing definitions and proposing a structured framework that captures the essential knowledge and skills required to engage with generative AI effectively. While AI literacy has been widely discussed, the emergence of generative AI introduces new cognitive and evaluative demands that require a clearer and more structured approach. This study aims to address these gaps by synthesizing insights from existing literature to establish a structured foundation for understanding generative AI literacy, ensuring greater clarity in research, education, and policy development. A well-defined conceptualization will contribute to a more coherent and actionable framework, guiding future discussions on how individuals can responsibly and critically interact with generative AI technologies.

To achieve this, our study draws upon revised Bloom's taxonomy, a well-established educational framework, to conceptualize generative AI literacy. Originally developed to classify educational objectives, revised Bloom's taxonomy emphasizes progressive cognitive engagement, ranging from foundational understanding to higher-order skills like analysis, evaluation, and creation [23]. These stages align closely with the demands of generative AI literacy, where users must not only understand AI mechanisms but also iteratively refine inputs, critically assess outputs, and responsibly create content in collaboration with AI systems. By adapting Bloom's taxonomy to the context of generative AI, this study establishes a structured framework that integrates technical proficiency, ethical responsibility, and societal awareness into each stage of learning. This approach ensures that learners develop a comprehensive skill set tailored to the complexities of generative AI technologies.

2. METHOD

2.1. Research questions

To address these challenges, this study aims to conceptualize generative AI literacy by critically examining existing definitions and proposing a structured framework. While various definitions of AI literacy exist, they often do not fully capture the unique cognitive, technical, and evaluative demands

associated with generative AI. As a result, there is a need to establish a structured understanding of what constitutes generative AI literacy. Therefore, this study seeks to answer the question: what are the gaps in existing conceptualizations of generative AI literacy, and how can they be addressed through a structured framework? By exploring prior conceptualizations, this research identifies key themes and theoretical gaps, ultimately contributing to a clearer and more comprehensive framework for understanding generative AI literacy.

2.2. The search and manuscript selection process

The search and manuscript selection process were designed to ensure a comprehensive and systematic identification of relevant literature on generative AI literacy. The process involved multiple stages, including database selection, keyword-based searches, and a rigorous screening procedure to identify eligible studies [24]. To capture a broad range of scholarly contributions, three key academic databases were utilized: Web of Science, Scopus, and Google Scholar [25], [26]. These databases were chosen for their extensive coverage of peer-reviewed articles, conference proceedings, and conceptual papers across disciplines [27]. A total of 60 articles were initially retrieved, with 12 from Web of Science, 21 from Scopus, and 27 from Google Scholar. The search strategy employed specific keywords to target literature directly related to generative AI literacy. The primary search terms included "generative AI literacy", "generative artificial intelligence literacy", and "generative artificial intelligence (AI) literacy". These terms were selected to encompass both theoretical and practical discussions of literacy in the context of generative AI [28].

To ensure relevance and methodological rigor, the selection process was systematically guided by specific inclusion and exclusion criteria. This approach was designed to filter literature effectively, ensuring that only highly relevant and credible sources informed our conceptual framework development. We specifically included peer-reviewed articles, conference proceedings, and conceptual papers. These publication types were prioritized due to their inherent academic vetting processes, ensuring the reliability and scholarly quality of the included literature [29], [30].

Crucially, included studies had to explicitly address generative AI literacy, distinguishing it from broader AI literacy discussions. Furthermore, we also prioritized studies that provided clear descriptions of underlying theories, methodologies, or frameworks directly related to generative AI literacy, as these were essential for synthesizing a robust conceptual model. Articles discussing pedagogical approaches and assessment methods related to generative AI literacy were also considered, as these offered practical insights into the application of the framework.

To ensure a global academic discourse perspective, only works published in English were considered. On the other hand, non-peer-reviewed sources, such as blog posts, opinion pieces, or non-academic websites, were systematically excluded. These sources, while potentially informative, typically lack the rigorous peer-review process necessary for scholarly research [31], [32]. A key exclusion criterion was also applied to studies that focused solely on general AI literacy without explicitly addressing the unique characteristics and challenges posed by generative AI, such as prompt engineering, critical evaluation of AI-generated outputs, and complex ethical considerations inherent to generative models. Finally, articles lacking sufficient detail on their theoretical foundations or practical applications, as well as duplicated publications or redundant content already captured in other databases, were filtered out to maintain conciseness and avoid redundancy.

The screening process followed a systematic two-step approach to ensure transparency and reliability [33]. To further enhance objectivity and minimize bias, the screening was independently conducted by two authors. In the first step, duplicates were removed, and titles and abstracts were screened to assess alignment with the predefined inclusion criteria.

This initial filtering reduced the pool of articles to 27 potential candidates. Any discrepancies or disagreements between the two reviewers regarding article inclusion were resolved through discussion and consensus, or by consulting a third author when necessary. In the second step, a full-text review was conducted to evaluate the remaining articles against the eligibility criteria. During this phase, studies that did not meet the inclusion criteria or failed to provide substantial insights into generative AI literacy were excluded. Following this rigorous evaluation, a final corpus of 20 articles was selected for inclusion in the review. These articles collectively represent a diverse range of perspectives on generative AI literacy, spanning theoretical frameworks, empirical studies, and ethical considerations. This structured approach to search and selection ensures that the review is grounded in credible and relevant academic literature, providing a robust foundation for synthesizing knowledge on generative AI literacy [34].

2.3. The data coding and analysis processes

The data coding and analysis processes were designed to ensure rigor and reliability in synthesizing the literature on generative AI literacy. A coding framework was developed based on prior definitions of AI literacy and emerging references to generative AI in the selected studies. This initial framework was

iteratively refined through multiple rounds of coding, where initial codes were applied to a subset of articles, reviewed for consistency, and adjusted based on emerging patterns and discussions among researchers.

To establish inter-rater reliability, an initial subset of 35% of the selected articles (7 articles) was coded by the primary researcher. These coded articles were then provided to a second independent researcher, who reviewed the assigned codes and assessed agreement on a binary scale (0= no agreement, 1= agreement). Cohen's Kappa was calculated to quantify inter-rater reliability, yielding a value of 0.83, which indicates strong agreement according to established benchmarks [35]. Discrepancies were identified and resolved through discussion to ensure consensus and consistency in coding.

For the synthesis strategy, thematic analysis using the constant comparative method was employed. This approach ensures a rigorous and systematic identification of recurring themes, contradictions, and relationships by continuously comparing codes across articles, grounding findings in the data itself [36], [37]. The constant comparative method was particularly suited for this study, as it enabled iterative refinement of themes, ensuring alignment with the research objectives while addressing the multidimensional nature of generative AI literacy. In addition, descriptive statistics, such as frequency counts and percentages, were used to summarize article characteristics, including publication year, study type, and geographic distribution, providing a quantitative overview of the dataset. Finally, the identified themes were mapped to the study's research question to ensure alignment with the study's objectives and facilitate a coherent presentation of findings. This systematic approach ensured that the analysis was both rigorous and comprehensive, providing a solid foundation for conceptualizing generative AI literacy.

3. RESULTS AND DISCUSSION

Before delving into the definitions and discussions surrounding generative AI literacy, it is important to provide an overview of the characteristics of the 20 articles included in this review. These articles were selected through a rigorous process aimed at ensuring relevance and credibility, as outlined in the methodology section. The analysis of their characteristics reveals trends in publication years, geographic distribution, publication types, and methodological approaches as shown in Table 1.

Table 1. Frequency (N, %) of the characteristics of the reviewed articles

Variables	Categories	N	Percentage (%)
Year	2023	2	10.0
	2024	17	85.0
	2025	1	5.0
Continent	North America	3	15.0
	Europe	7	35.0
	Asia	8	40.0
	Oceania	2	10.0
	Africa	1	5.0
Publication type	Book chapter	1	5.0
	Conference paper	3	15.0
	Journal article	13	65.0
	Research paper	1	5.0
	Review paper	2	10.0
Methodological approach	Empirical study	10	50.0
	Review study	2	10.0
	Theoretical framework	5	25.0
	Case study	1	5.0
	Scale development	1	5.0

First, the temporal distribution of the articles highlights the rapid growth of interest in generative AI literacy. The majority of the reviewed articles (17 or 85%) were published in 2024, reflecting the field's increasing prominence and the urgency with which researchers are addressing its challenges. Only two articles (10%) date back to 2023, and one article (5%) was published in early 2025. This recent surge underscores the promising yet rapidly evolving nature of generative AI literacy as a research domain.

Geographically, the reviewed articles reflect a diverse range of contributions from multiple continents. Asia leads with the highest number of articles, contributing eight publications (40%), followed by Europe with seven articles (35%). North America accounts for three articles (15%), while Oceania and Africa contribute two articles (10%) and one article (5%), respectively. Notably, some contributions involve international collaborations, such as those between Turkey and Azerbaijan or the United Kingdom and China. This geographic diversity highlights the global engagement with generative AI literacy and underscores the importance of cross-cultural perspectives in addressing its challenges and opportunities.

In terms of publication types, journal articles dominate the corpus accounting for 13 of the 20 articles (65%). Conference papers make up 3 articles (15%), while book chapters, research papers, and review papers each contribute one article (5% each). This distribution reflects the academic community's preference for peer-reviewed journal publications to disseminate findings on generative AI literacy, though conference proceedings and other formats also play a role in advancing the field.

The methodological approaches employed in these studies further illustrate the multidisciplinary nature of generative AI literacy research. Empirical studies constitute the largest category, with 10 articles (50%) utilizing methods such as surveys, experiments, and field studies to investigate practical applications and outcomes. Theoretical frameworks are the next most common approach, appearing in five articles (25%), which focus on conceptualizing generative AI literacy and proposing models or guidelines. Additionally, two articles (10%) are review studies that synthesize existing literature, while case studies and scale development each account for one article (5%). This variety in methodologies highlights the field's dynamic interplay between theory and practice, as well as its reliance on both qualitative and quantitative insights.

Overall, the characteristics of the reviewed articles reveal a vibrant and rapidly expanding research landscape. The concentration of publications in recent years, coupled with geographic and methodological diversity, underscores the urgency and complexity of addressing generative AI literacy. These trends set the stage for a deeper exploration of how generative AI literacy is conceptualized, including its definitions and core components. Given this rapidly expanding research landscape, the next section examines how generative AI literacy has been defined across these studies, identifying common themes and conceptual gaps.

3.1. Toward a comprehensive definition of generative AI literacy

From the 20 articles systematically reviewed, several key publications were identified as highly influential in the current discussion on generative AI literacy. To help guide the reader, these key publications were selected. Table 2 summarizes these selected works, detailing their primary focus and relevance before the following in-depth analysis.

Table 2. Summary of key articles that shape the discourse on defining generative AI literacy

Source	Title	Focus and relevance
[38]	What is AI literacy? Competencies and design considerations	Establishes a foundational competency framework that serves as a benchmark for the field. This review utilizes it as a baseline to demonstrate the conceptual gaps that emerge when applying traditional AI literacy models to the unique demands of generative AI.
[39]	Conceptualizing AI literacy: an exploratory review	Presents a four-dimensional framework for general AI literacy. Its analysis within this review reveals the structural limitations of conventional models in adequately capturing the dynamic and co-creative nature of user engagement with generative AI.
[40]	Measuring user competence in using AI: validity and reliability of AI literacy scale	Investigates the valid measurement of user competence in AI with a focus on bias. The findings reinforce this review's argument that conventional literacy models do not sufficiently address the amplified challenges of accountability and fairness inherent in generative systems.
[41]	Unleashing the potential of generative AI, conversational agents and chatbots in educational praxis	Proposes a targeted definition of generative AI literacy centered on the ability to understand, interact with, and critically evaluate these technologies. Its introduction marks a significant scholarly transition from general AI competencies toward the specialized literacies required by generative systems.
[12]	Generative AI literacy: twelve defining competencies	Details a practical, competency-based model with twelve core skills for responsible AI use. It exemplifies the contemporary trend toward skill-centric frameworks and is synthesized in this review to inform the development of the proposed multidimensional model.
[42]	Why generative AI literacy, why now and why it matters in the educational landscape?	Introduces the adaptive '3wAI' framework (know what, how, why), designed to evolve with the technology. It is a primary subject of the comparative analysis in this review, representing a flexible approach to conceptualizing generative AI literacy.
[43]	Generative AI literacy in nursing education: a crucial call to action	Contextualizes the need for generative AI literacy within the high-stakes professional field of nursing. The study serves to ground the theoretical discussion by illustrating the practical imperatives and tangible consequences of literacy in a professional setting.

The concept of generative AI literacy has gained increasing attention as AI technologies continue to evolve, necessitating a distinct and comprehensive theoretical foundation. While AI literacy has been broadly

discussed in academic literature, many existing definitions are framed in relation to conventional AI systems, such as machine learning models used for classification, decision-making, and automation [20], [44]. However, generative AI introduces unique challenges and demands that extend beyond the scope of traditional AI literacy [45]. Unlike conventional AI, which focuses on analysis and prediction, generative AI is designed to create novel content, requiring users to engage in iterative prompt engineering, content evaluation, and ethical reasoning [41]. This shift in interaction highlights the need to re-examine AI literacy frameworks to ensure they adequately reflect the skills and knowledge required for engaging with generative AI tools.

Several definitions of AI literacy have been proposed in recent years, but significant gaps remain in addressing the unique demands of generative AI literacy. One of the most widely cited definitions, proposed by [38] describes 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." While this definition provides a broad conceptual foundation, it tends to focus on static interactions with AI, assuming that AI functions as a fixed tool rather than a dynamic system requiring iterative human engagement [12], [46]. As a result, it does not fully address the unique skills needed to refine AI-generated content, critically assess outputs, or navigate ethical dilemmas associated with generative AI.

In response to these limitations, some scholars have sought to refine AI literacy definitions to better reflect the demands of generative AI. For instance, Bozkurt [41] provides a valuable step forward by offering a more targeted definition of generative AI literacy as "proficiency in understanding, interacting with, and critically evaluating generative AI technologies." This definition usefully emphasizes active user engagement with generative AI systems, moving beyond passive comprehension of AI principles.

However, it could benefit from greater specificity regarding the depth of knowledge required or the mechanisms through which individuals develop such proficiency. Similarly, Annapureddy *et al.* [12] proposes a practical and actionable competency-based model that identifies twelve core skills for responsible interaction with generative AI. While this framework offers a helpful foundation for application, its theoretical underpinnings could be strengthened to better explain how these competencies interconnect within a broader literacy framework. We do believe both contributions highlight important advancements but also reveal opportunities for further refinement in capturing the full complexity of generative AI literacy.

Efforts to structure AI literacy more systematically have led to the development of conceptual frameworks that attempt to categorize key competencies. Bozkurt [42] introduces the 3wAI framework, a three-dimensional model comprising foundational knowledge ("know what"), practical application ("know how"), and ethical and societal awareness ("know why"). Unlike traditional linear frameworks, the 3wAI framework is explicitly designed to be adaptive and flexible, acknowledging the rapidly evolving nature of generative AI and the need for literacy to evolve alongside technological advancements. For example, Bozkurt [42] emphasizes that AI literacy should be a "liquid and rapidly updatable concept," with guiding questions that allow users to reassess competencies as AI tools change. This approach aligns with the dynamic demands of generative AI, where users must iteratively refine inputs and adapt to evolving outputs.

However, while 3wAI framework [42] offers a valuable adaptive and flexible approach to generative AI literacy, opportunities for refinement still remain. Specifically, we argue that the framework could benefit from greater granularity in addressing ethical and societal challenges such as algorithmic bias, environmental impacts of training large models, and legal considerations around intellectual property. Additionally, incorporating a distinct dimension or components focused on proactive measures to identify and combat harm such as misinformation, deepfakes, or AI-generated bias would strengthen its alignment with the dynamic and high-stakes nature of generative AI interactions. These enhancements would build on the framework's existing strengths while addressing critical gaps highlighted in broader research on responsible AI engagement.

Another widely referenced framework, proposed by Ng *et al.* [39], defines AI literacy through four dimensions: know and understand, use and apply, evaluate and create, and ethics. This model served as the basis for the generative AI literacy assessment test (GLAT) [46], which attempts to measure generative AI literacy across these dimensions. While the framework provides a structured foundation for assessing AI literacy, it does not fully capture the iterative and creative processes inherent in generative AI interactions. Scholars such as [12] have noted that this framework tends to oversimplify the complexities of user engagement with generative AI, failing to account for the fact that proficiency in generative AI literacy requires continuous adaptation and refinement. Moreover, the dimension of "evaluate and create" does not explicitly address the emergence of AI-generated misinformation, biases, and content authenticity concerns, all of which are critical elements of generative AI literacy.

Beyond technical and ethical challenges, generative AI literacy must also address its societal implications, a dimension often underemphasized in existing frameworks [17], [47]. Unlike traditional AI systems that analyze existing data, generative AI creates new content such as synthetic media, deepfakes, and

AI-generated art which had raising unique concerns about authenticity, bias, and manipulation [42]. For instance, in nursing education, students using AI-generated materials must critically assess their accuracy and ethical relevance, as highlighted by [43]. Similarly, disciplines like journalism and healthcare, where AI-generated content is increasingly prevalent, require users to navigate issues of accountability and bias awareness, which [40] argue are inadequately addressed in conventional AI literacy models. These examples underscore the necessity of integrating societal awareness into generative AI literacy frameworks, ensuring users can engage with these technologies in ways that mitigate harm and promote equity.

Given the limitations and inconsistencies in existing definitions, this study proposes a new conceptualization of generative AI literacy that integrates technical proficiency, ethical responsibility, and societal awareness into a cohesive framework. Generative AI literacy should be understood as a multidimensional competency that enables individuals to engage effectively with AI-generated content through iterative refinement, critical assessment, and ethical judgment. Unlike conventional AI literacy, which often focuses on understanding algorithms and evaluating AI technologies from a general perspective, generative AI literacy requires users to actively shape AI outputs, engage in continuous refinement processes, and develop the skills to assess content credibility, detect biases, and navigate ethical dilemmas associated with AI-generated information.

A comprehensive definition of generative AI literacy must account for its fluid and adaptive nature, recognizing that effective engagement with generative AI extends beyond technical skills to include cognitive flexibility, interpretive reasoning, and ethical responsibility. Users must not only understand the mechanisms behind generative AI but also develop the ability to critically evaluate its outputs, modify their inputs based on AI responses, and anticipate potential risks associated with AI-generated misinformation. As generative AI tools increasingly influence content creation, decision-making, and public discourse, literacy in this domain must also include awareness of societal impacts, regulatory considerations, and the broader implications of AI-driven narratives in various fields. By integrating these elements, we believed that generative AI literacy can be conceptualized as a dynamic and evolving skill set that integrates technical proficiency, ethical responsibility, and societal awareness. This multidimensional competency enables individuals to navigate the complexities of generative AI technologies, from understanding foundational models to critically engaging with their societal implications. The following section explores these dimensions in detail, establishing a structured competency framework.

3.2. A proposed framework for generative AI literacy

Building on the critique of existing definitions and frameworks, this study introduces a new generative AI literacy framework designed to address the limitations and inconsistencies highlighted in prior work. The framework adapts Bloom's taxonomy [23] by streamlining it to five progressive stages while integrating insights from previous models proposed by [38], [39], [42]. Our adaptation of Bloom's taxonomy builds on the revised Bloom's taxonomy [23], which prioritizes action-oriented verbs like creating and evaluating. While Bloom's taxonomy, in its traditional form, has been critiqued for its linear progression and primarily cognitive focus [48], our adapted framework strategically addresses these limitations.

It deliberately excludes the 'remember' stage [48], aligning with established critiques, and emphasizes active engagement and critical reasoning over passive recall. Our approach parallels Andrew Churches' Bloom's digital taxonomy (BDT) [49], which modernizes the framework for technology-enhanced environments. However, we refine it further to address the distinct challenges and opportunities presented by generative AI. This comprehensive design uniquely integrates the crucial dimensions of technical proficiency, ethical responsibility, and societal awareness into each stage of learning, ensuring a more balanced theoretical foundation. Although alternative educational frameworks exist, this adapted Bloom's taxonomy offers a familiar yet robust structure for conceptualizing the progressive development of competencies within this emerging domain. To achieve this, each stage incorporates these three core dimensions, grounded in the study's proposed definition of generative AI literacy as a dynamic and multidimensional competency. Together, they form the foundation of generative AI literacy and reflect the unique demands of interacting with AI systems designed to generate novel content. Figure 1 visually presents this framework, illustrating its core components and their interrelationships.

Technical proficiency focuses on the ability to comprehend and effectively use generative AI tools. This includes understanding foundational AI models such as GANs, diffusion models, and LLMs. It also encompasses practical skills like prompt engineering and troubleshooting errors. Ethical responsibility emphasizes the need for users to critically evaluate the ethical implications of AI-generated content. This involves recognizing biases in training data, addressing algorithmic fairness, and mitigating risks associated with misinformation, deepfakes, and intellectual property concerns. Societal awareness broadens the scope of generative AI literacy by highlighting its impact on industries, communities, and global digital ecosystems. This dimension encourages learners to consider how AI technologies shape public discourse, creativity, knowledge production, and cultural narratives. It also addresses legal frameworks, regulatory efforts, and

governance challenges. By embedding these three dimensions into each stage of the framework, learners progressively deepen their knowledge and engagement with generative AI. They develop foundational skills, practical competencies, critical evaluation abilities, and the capacity for responsible innovation.

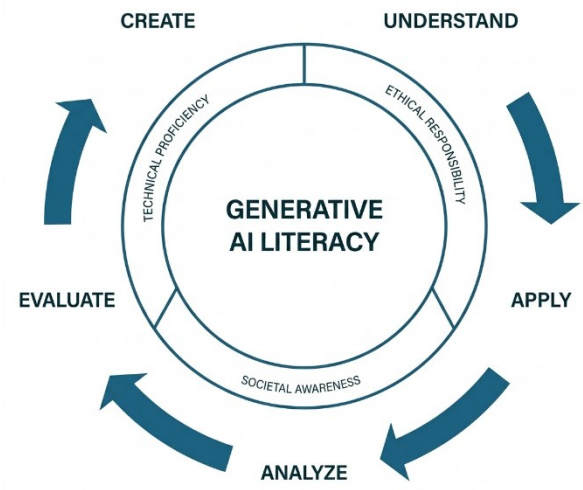

Figure 1. The proposed generative AI literacy framework

The hierarchical structure of the framework is visually represented in Table 3. This table provides a detailed breakdown of the competencies associated with each stage. This progression illustrates how learners advance from foundational understanding to creative application, ensuring a comprehensive skill set tailored to the complexities of generative AI technologies. The framework's adaptation of Bloom's taxonomy ensures that technical proficiency, ethical responsibility, and societal awareness are integrated into every stage of learning. This structured approach not only clarifies the essential components of generative AI literacy but also provides educators, policymakers, and researchers with a foundation for designing curricula, training programs, and assessment approaches. Ultimately, this multidimensional and hierarchical framework ensures that learners are prepared to use generative AI tools effectively while engaging with these technologies in ways that are ethical, inclusive, and socially impactful.

Table 3. A detailed breakdown of technical proficiency, ethical responsibility, and societal awareness competencies at each stage of the proposed framework

Stage	Technical proficiency	Ethical responsibility	Societal awareness
Understand	Grasp generative AI basics, operational mechanisms, and key models like GANs diffusion models, and LLM.	Recognize bias in AI training data and the need for transparency.	Understand AI's role in media and public discourse.
Apply	Use AI tools effectively (e.g., prompt engineering, troubleshooting).	Ensure AI applications align with ethical standards and do not cause harm.	Consider AI's impact on marginalized communities.
Analyze	Assess AI-generated content for accuracy, quality, and bias, including the ability to detect AI 'hallucinations'.	Evaluate consequences of biased/misleading AI-generated content.	Examine AI's role in journalism, education, and healthcare.
Evaluate	Critically assess ethical and governance challenges in AI.	Address concerns of algorithmic bias, deepfakes, and misinformation.	Consider AI's effects on industries and social structures, including its alignment with legal and regulatory frameworks.
Create	Collaborate with AI to generate meaningful and original content.	Ensure AI-generated works adhere to ethical and inclusive principles.	Use AI to solve societal challenges and innovate responsibly.

The proposed framework provides a structured approach to generative AI literacy by integrating three core dimensions of technical proficiency, ethical responsibility, and societal awareness across five

progressive stages which are understand, apply, analyze, evaluate, and create. This hierarchical design ensures that learners develop a comprehensive skill set tailored to the unique demands of interacting with generative AI technologies. By embedding these dimensions into each stage, the framework reflects the iterative and multidimensional nature of engaging with AI systems designed to generate novel content. The following sections delve into each stage in detail, outlining the specific competencies associated with technical proficiency, ethical responsibility, and societal awareness. Together, these components form a cohesive foundation for fostering generative AI literacy, equipping learners to use these tools effectively while navigating their ethical and societal implications.

At the foundational level, the understand stage focuses on developing a basic comprehension of generative AI systems and their broader implications. Learners begin by grasping fundamental concepts such as the definition of generative AI, its operational mechanisms, and key models like GANs, LLM, and diffusion models. From a technical perspective, they are introduced to the principles of prompt engineering and the underlying algorithms that drive AI-generated content [41]. Ethical responsibility is also cultivated at this stage as learners recognize biases embedded in training data and the importance of transparency in generative AI systems [43]. Societal awareness is developed by exploring AI's role in shaping media narratives and influencing public opinion, providing learners with a contextual understanding of its societal impact [50].

As learners progress to the apply stage, they transition from theoretical understanding to practical application. Technical proficiency is demonstrated through hands-on engagement with generative AI tools, such as crafting effective prompts and troubleshooting errors when working with platforms like ChatGPT, DALL-E, or stable diffusion [12], [51]. Ethical responsibility is reinforced by ensuring that AI applications align with ethical standards and do not perpetuate misinformation or cause harm. Societal awareness is further developed by prompting learners to consider how their use of generative AI affects diverse communities, particularly marginalized groups, fostering an inclusive approach to AI engagement [12].

The analyze stage builds on this foundation by equipping learners with the ability to critically assess AI-generated outputs. From a technical perspective, learners are trained to identify inconsistencies or biases in outputs, such as inaccuracies in generated text or images, and to specifically verify content to detect AI 'hallucinations,' such as fabricated references or data. Ethical considerations at this stage involve evaluating the potential consequences of deploying flawed or biased AI-generated content, ensuring accountability and fairness in AI applications [43]. Societally, learners examine the influence of AI-generated content in fields such as journalism, education, and healthcare, determining whether its use aligns with broader societal values and ethical norms [40].

At the evaluate stage, learners engage in informed judgments about the ethical and societal implications of generative AI. Drawing from [42] "3wAI framework," this phase integrates foundational knowledge of AI, practical application, and ethical and societal considerations. Ethical responsibility is emphasized as learners critically assess issues such as algorithmic bias, deepfakes, and the misuse of AI-generated content in media, politics, and entertainment [42]. Additionally, learners evaluate governance challenges such as accountability, transparency, and equitable access, considering how these factors shape the deployment of AI technologies [43]. Societal awareness is reinforced by examining the broader impact of generative AI on industries and communities, including its alignment with legal and regulatory frameworks, and addressing concerns such as the exacerbation of inequalities and disruptions in traditional sectors.

Finally, at the highest level, the create stage encourages learners to leverage generative AI tools for creative and meaningful contributions. Technical proficiency is demonstrated through collaboration with AI to generate original content, whether in the form of visual art, writing, or educational resources. Ethical responsibility remains integral, ensuring that AI-generated creations adhere to ethical and inclusive principles and avoid harm or exploitation [43]. Societal awareness is further reinforced by prompting learners to consider how their AI-driven creative work can contribute positively to society, fostering innovation while addressing real-world challenges [52]. This stage signifies a shift from passive consumption to active and responsible participation in AI-mediated creativity.

The accompanying table provides detailed breakdowns of this progression. By proposing this framework, we contribute to the ongoing discourse on generative AI literacy [43], offering educators, policymakers, and researchers a foundation to design curricula, training programs, and assessment approaches that address the ethical, societal, and technical challenges posed by AI technologies. Ultimately, this multidimensional and hierarchical approach equips learners to navigate the complexities of generative AI technologies, empowering them to harness their creative potential while addressing the ethical and societal challenges that accompany their widespread adoption. As generative AI continues to reshape industries, education, and public discourse, fostering literacy in this domain is essential for building a future that is equitable, transparent, and resilient. Ongoing refinement of this framework will be necessary to address emerging challenges and ensure its relevance in an ever-changing technological landscape.

The practical utility of this proposed framework extends to various real-world contexts, offering a structured guide for integrating generative AI literacy into educational and industrial settings. In educational

contexts, the framework can inform the design of progressive learning objectives and curricula, moving learners from basic comprehension to advanced creative application of generative AI tools. For instance, educators can use the five cognitive stages to structure modules that build technical proficiency in prompt engineering, ethical responsibility in evaluating AI outputs, and societal awareness of AI's broader implications. Similarly, within industrial settings, the framework serves as a blueprint for developing targeted professional training programs. It enables organizations to cultivate a workforce capable of discerning AI 'hallucinations,' navigating intellectual property concerns, and innovatively leveraging generative AI for problem-solving and content creation, thereby fostering responsible and effective AI integration across sectors.

To operationalize the proposed framework in an authentic learning scenario, consider the case of a university student engaging with generative AI for a research assignment. At the 'understand' stage, the student recognizes both the capabilities and limitations of the tool, including its potential for 'hallucination' and the institutional expectations for academic integrity. During the 'apply' stage, the student uses the AI to brainstorm ideas and generate preliminary content, all while maintaining ethical boundaries regarding authorship and originality. In the 'analyze' stage, the student critically evaluates the AI-generated material by checking factual accuracy, identifying potential biases, and verifying all sources to mitigate fabrications. The 'evaluate' stage then prompts the student to reflect on their own decision-making process, ethical conduct, and the broader societal implications of their choices, including data privacy and intellectual property concerns.

Finally, at the 'create' stage, the student integrates validated content with their own insights to construct an original academic argument. Where necessary, the student may loop back to revise prompts or reassess their sources, highlighting the recursive and dynamic nature of AI-literate practice. This cycle exemplifies how generative AI literacy extends beyond technical proficiency to encompass critical reasoning, ethical reflection, and socially responsible action.

4. CONCLUSION

The rapid evolution of generative AI' has reshaped industries and education, demanding a clearer understanding of the competencies required for responsible engagement. This review successfully conceptualizes generative AI's literacy by proposing a structured competency framework that integrates technical proficiency, ethical responsibility, and societal awareness across progressive cognitive stages. This framework directly addresses critical gaps in existing conceptualizations by clarifying the distinct demands of generative AI's literacy, including challenges such as prompt engineering, iterative refinement, critical evaluation of AI-generated content, bias, misinformation, and authenticity. Although the framework offers a strong theoretical basis, we must acknowledge its limitations. By focusing exclusively on peer-reviewed articles in English, our review may not capture the full spectrum of global perspectives on this topic which potentially narrow the diversity of perspectives. Moreover, the evolving nature of generative AI itself means that conceptual models must be continuously refined to keep pace with technological advancements. Looking ahead, this work points toward several promising paths for future research, including the need for empirical studies to test and validate the proposed framework, particularly within real-world industrial and educational settings. Comparative cross-cultural studies are also needed to explore differing societal conceptualizations of generative AI's technologies, and longitudinal research is essential to determine how this literacy evolves over time as generative AI's systems become more integrated into everyday life. Overall, this framework can also serve as a flexible guide for curriculum development and organizational training, moving beyond mere tool usage to equip individuals with the critical thinking and ethical reasoning skills necessary for responsible engagement in diverse contexts such as journalism, education, and healthcare. Its continued relevance will be ensured through ongoing interdisciplinary collaboration and theoretical development in this dynamic landscape.

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C : **C**onceptualization
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Vi : **Vi**sualization
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P : **P**roject administration
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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

Not applicable, this study did not involve human subjects, personal data collection, or any identification of individuals requiring informed consent. Privacy protection remains upheld as no participant information was gathered, ensuring compliance with legal rights without the need for consent documentation.

ETHICAL APPROVAL

Not applicable, no human subjects or animal use was involved in this research; thus, institutional review board approval, Helsinki Declaration tenets, or animal care policies do not apply. The study adhered to general research integrity standards through computational methods and publicly available data only.

DATA AVAILABILITY

The data that supports the findings of this study are available from the corresponding author, [MEEMM], upon reasonable request.

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