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# Developing AI Education Competency Framework: A Systematic Literature Review

RESEARCH ARTICLE

MALISSA MARIA MAHMUD
WALI KHAN MONIB
ATIKA QAZI
SHIAU FOONG WONG
CHANDRA REKA RAMACHANDIRAN
SITI NORBAYA AZIZAN

*Author affiliations can be found in the back matter of this article

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## ABSTRACT

Artificial Intelligence (AI) is rapidly transforming education, yet many institutions lack a comprehensive framework to integrate AI effectively. This paper develops an AI Education Competency Framework to guide the integration of AI in educational settings through a systematic literature review. Methodologically, a rigorous systematic literature review (SLR) was conducted following PRISMA guidelines, ensuring methodological rigor and empirical grounding. Key databases (e.g., Google Scholar, IEEE Xplore, SpringerLink) were searched for studies on AI frameworks in education, yielding 21 relevant sources. The analysis resulted in a novel framework which is built on four pillars—Foundation, Integration, Innovation, and AI Citizenship, encompassing fundamental AI knowledge, curricular and administrative integration, AI-driven innovation in pedagogy, and ethical AI use. The proposed framework informed by findings from these studies, addressing gaps such as the lack of unified approaches that combine technical, pedagogical, and ethical dimensions. The framework provides a holistic strategy for AI integration in education, including for open and distance education contexts, bridging theoretical and practical aspects. In discussion, we highlight the framework's contributions in filling identified gaps, its potential implementation challenges, and recommendations for educators and policymakers. The study concludes that the AI Education Competency Framework offers significant contributions by aligning AI advancements with educational competencies, ensuring stakeholders are prepared to navigate AI's complexities responsibly and effectively.

**CORRESPONDING AUTHOR:**
**Malissa Maria Mahmud**
Sunway University, Malaysia
malissam@sunway.edu.my

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artificial intelligence; AI; education; framework; AI integration; pedagogical innovation; ethical use; citizenship; open education; distance education

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## INTRODUCTION

The integration and ethical use of artificial intelligence (AI) in education has become a focal point for educational institutions worldwide. Educators and administrators face mounting pressure to leverage AI advancements to enhance teaching, learning, and administrative processes. However, the rapid growth of AI applications has outpaced the development of frameworks to guide their effective and responsible use in educational contexts, particularly with the emergence of generative AI tools that introduce new pedagogical and ethical considerations. Current research, discussed in detail in the literature review section, often addresses isolated aspects of AI in education, such as curriculum design, teacher training, or ethical guidelines, without offering a unified, scalable model that ties these elements together (e.g., Thongprasit & Wannapiroon, 2022; Xu & Ouyang, 2021; Lameras et al., 2022). This fragmentation can lead to inefficient implementations and ethical pitfalls. There is a critical need for a holistic framework that spans theoretical knowledge, practical applications, and ethical considerations of AI in education.

This paper presents the development of an AI Education Competency Framework, developed primarily for higher education but intended for broader application across a range of AI technologies, including generative AI. The primary objective of the framework is to provide a structured, comprehensive approach for integrating AI into educational settings, ensuring that both academic and operational dimensions are effectively addressed. The framework is designed around four key pillars: Foundation, Integration, Innovation, and AI Citizenship, each targeting a specific dimension of AI application in education. Together, these pillars encompass foundational AI knowledge, continuous professional learning, innovative pedagogical methods, and ethical AI use. By consolidating these elements into one model, the framework seeks to prepare students, educators, and higher education institutions to navigate AI's complexities responsibly and effectively.

This study conducts a systematic literature review (SLR) to ensure that the proposed AI Education Competency Framework is grounded in existing scholarship and best practices. The SLR enabled us to synthesize current research, theories, and frameworks related to AI competencies in education, thereby strengthening the theoretical foundation of our work. By analyzing a diverse body of literature, we identified critical gaps: while various AI literacy and competency models exist, none fully address all facets of AI integration (technical, pedagogical, and ethical) within a single comprehensive structure. Additionally, despite their wide adoption and recognized value in integrating knowledge, skills, and ethical considerations, competency frameworks have been criticized due to several reasons including task-based, inconsistent in terminology and application, as well as externally imposed (Katoue & Schwinghammer, 2020; Curry & Docherty, 2017), which can limit their alignment with holistic, socio-cultural learning approaches. This study therefore seeks to answer the research question: How can a unified AI Education Competency Framework be designed to integrate these facets and guide effective AI implementation in education? In response, we propose a unified competency framework that integrates these facets, aiming to provide both theoretical insight and practical guidance for educators, administrators, and institutions.

In the following sections, we outline the relevant literature, describe our systematic review methodology, present the resulting AI Education Competency Framework, and discuss its implications. We emphasize how the framework advances the field of AI in education by providing a high-impact, empirically grounded model for AI integration. Ultimately, this work contributes to both theory and practice, offering guidance for educators, administrators, and policymakers to harness AI's potential in higher education while upholding rigorous scientific and ethical standards.

## LITERATURE REVIEW

Research on AI in education has expanded rapidly in recent years, producing a diverse array of studies on AI literacy, competency frameworks, models, and educational applications of AI (Santana & Díaz-Fernández, 2022; Laupichler et al., 2022; Faruqe et al., 2021; Picasso et al., 2024). This section synthesizes key findings from the literature to establish a theoretical foundation and identify gaps that the proposed framework will address. Broadly, existing

studies fall into several themes: reviews of AI in education, definitions of AI literacy and competencies, domain-specific AI competency frameworks, practical AI applications and innovation in education, and ethical and societal considerations.

## REVIEW OF AI IN EDUCATION

Early comprehensive reviews underscored the need for robust competency frameworks to guide AI integration. For example, Zawacki-Richter et al. (2019) conducted a systematic review of AI applications in higher education, revealing disciplinary trends in research (e.g., emphasis on academic support systems and intelligent tutoring) and calling for a cohesive AI competency framework. Similarly, Zhai et al. (2021) reviewed AI in education from 2010 to 2020, categorizing research into developmental, applicational, and integrational layers. They identified persistent challenges such as ethical issues and evolving teacher/student roles, reinforcing the importance of comprehensive strategies for AI integration. Additionally, Monib et al. (2024a), in their review of generative AI in education focusing on ChatGPT, identified several challenges, such as plagiarism, accountability, bias, loss of soft skills, the digital divide, and privacy risks, and provided relevant strategies. The review recommended further research to provide a more comprehensive understanding of generative AI.

These broad reviews highlight that, despite numerous AI tools and pilot programs in education, educators lack an overarching framework to tie these initiatives together.

## AI LITERACY AND COMPETENCIES

A critical strand of literature attempts to define what knowledge and skills constitute "AI literacy" or "AI competency". Definitions vary across studies. Long and Magerko (2020), for instance, proposed 17 competencies and 15 design considerations for AI literacy, aiming to help users understand and critically evaluate AI. Their work provides a baseline for what an AI-literate individual should know (e.g., understanding AI capabilities and limitations) and how educational tools should be designed to foster this understanding. Picasso et al. (2024) proposed a model for critical data and AI literacies, highlighting knowledge, skills, and ethical/civic dimensions, demonstrating one approach to defining and conceptualizing AI literacy. Another study examined the intersection of information literacy and AI, suggesting that higher education must cultivate both technical skills and cognitive competencies to prepare students for AI's impact on workplaces (Lau et al., 2019). This aligns with broader calls for integrating AI topics into curricula to ensure students possess essential 21st-century skills (Shin 2019; Shin, 2021).

Domain-specific perspectives further enrich the definition of AI competencies. Kim et al. (2021) applied the Technological Pedagogical Content Knowledge (TPACK) framework to identify teacher competencies needed for K-12 AI education. In line with Ng et al. (2023), they emphasized that educators require not only technical AI knowledge but also pedagogical strategies to effectively integrate AI into teaching. Correspondingly, Tenório and Romeike (2023) identified competencies for non-computer science undergraduates, highlighting foundational AI knowledge and responsible AI use as critical for all students, not just computer science majors. These studies underscore that AI competencies must be tailored to the audience (teachers, computer science (CS) majors, non-CS students, etc.) yet also share common elements like understanding AI concepts and ethics.

## PRACTICAL AI APPLICATIONS AND INNOVATION IN EDUCATION

Another theme in the literature is the exploration of AI applications to improve educational practice and how these relate to needed competencies. Anton et al. (2020) took an industry-oriented approach by analyzing thousands of job postings to distill key technical and managerial competencies for AI use. Their findings, emphasizing skills like data analysis, AI tool usage, and project management, highlight the competencies individuals need to exploit AI technologies effectively in professional settings. In the K-12 context, Huang (2021) provided empirical evidence that introducing AI courses at the secondary level can significantly enhance students' knowledge, teamwork, and learning skills. Such studies demonstrate tangible benefits of AI education initiatives and inform which competencies (e.g., collaboration, problem-solving with AI) should be cultivated.

Historical perspectives also inform current frameworks. As early as 1996, Beck et al. (1996) identified components of intelligent tutoring systems: Student Model, Pedagogical Module, Domain Knowledge, Communication Module, and Expert Model. These components remain relevant as core areas where AI interacts with educational processes, implying that effective AI integration requires understanding and designing around each component. More recently, Schleiss et al. (2023) developed a planning framework for designing AI education courses, bridging traditional course development and innovative AI integration. Such work provides practical guidance on course-level innovation, complementing higher-level competency frameworks.

In terms of cutting-edge AI applications, generative AI has become a focus. Van den Berg (2024) found that educators use generative AI like ChatGPT to improve teaching tasks such as lesson planning, assessments, and text simplification, while noting the need for ethical guidelines and awareness of AI's limits. Su and Yang (2023) explored the use of ChatGPT in education and proposed the IDEE framework (identify outcomes, determine automation level, ensure ethics, evaluate effectiveness) for integrating generative AI tools. Their study indicates that educators need competencies not just in using AI, but in managing automation and ethical implications of AI-driven content generation. Other studies on ChatGPT as a learning assistant (Monib et al., 2024a) and ChatGPT in personalized learning (Monib et al., 2024b; Monib et al., 2025) emphasized the need for well-defined guidelines to ensure the ethical and responsible use of ChatGPT and other GenAI tools in education. This further reinforces that an AI competency framework must encompass innovation and ethics hand-in-hand.

## ETHICAL AND SOCIETAL CONSIDERATIONS

Bozkurt (2023) emphasized the need for responsible integration of AI in education, highlighting challenges such as ensuring the quality and reliability of AI-generated content, addressing data privacy concerns, and promoting equitable access to AI technologies. Ethical AI use is a recurrent theme across the literature, highlighting the need for *AI citizenship* competencies. Holmes et al. (2022) proposed a community-wide ethical framework for AI in education, focusing on principles like fairness, accountability, transparency, bias mitigation, autonomy, and inclusion. This underscores that any comprehensive AI education framework must integrate ethics as a core component, ensuring that students and educators understand AI's societal impacts and practice responsible AI use. Additionally, Chiu et al. (2024) argued that confidence and self-reflection should be included in AI literacy frameworks to support non-engineering learners. This insight broadens the typical ethical discourse by suggesting that personal dispositions (e.g., confidence in using AI) are part of competency.

Studies focusing on specific contexts also stress inclusivity and global perspectives. Sanusi et al. (2022) examined AI literacy in Nigerian secondary schools, finding that collaborative learning and cultural context play important roles in developing AI competencies. Their work highlights that frameworks should be adaptable to different cultural and resource contexts, ensuring global relevance. Similarly, Albashiry et al. (2024) developed a digital competency framework for university faculty to enhance resilience in the face of disruptions (like the COVID-19 pandemic), implicitly acknowledging open AI technologies as part of future-ready teaching competencies.

With the rapid development and adoption of AI, its environmental and sustainability consequences warrant close ethical and societal consideration. Concerns such as energy consumption and carbon emissions have been increasingly recognized in the broader AI ethics discourse (Chauhan et al., 2024; Khan et al., 2025). However, with regards to the educational aspect of AI integration, particularly generative AI, many studies focused on teaching and learning of sustainability (e.g., AlSagri & Sohail, 2024; Allam et al., 2025), rather than sustainability of AI integration in education itself. Highlighting this issue is critical, as sustainable AI integration must consider not only social and ethical responsibilities but also the long-term ecological implications of technological interventions in education.

## IDENTIFIED GAPS

Across these studies, several critical gaps are evident. Foremost is the absence of a unified framework that brings together the diverse threads of AI integration in education. Many efforts address one dimension (e.g., ethics, or technical skills, or pedagogy) in isolation. For instance,

one study may propose an ethical guideline framework, while another outlines technical competencies for teachers; educators are left without guidance on how to implement AI in a way that concurrently addresses pedagogy, technology, and ethics (Chan, 2023). Additionally, longitudinal evidence on AI's impact in education is scarce. Few studies track how AI integration affects student learning or institutional outcomes over time, which makes it challenging to refine frameworks based on what works long-term. The definitions of AI literacy and competency also vary widely, leading to inconsistencies in curricular and training models (Fakhri et al., 2024; Laupichler et al., 2022).

In summary, the literature establishes a strong foundation and need for the present study. It shows that while significant progress has been made in identifying pieces of the AI-in-education puzzle, there remains a critical need for a comprehensive, empirically grounded framework that unifies these pieces. Our AI Education Competency Framework is designed in response to these gaps, drawing upon the insights from prior work. In developing it, we incorporate the multiple dimensions identified above: foundational AI knowledge, curriculum integration strategies, innovative AI applications, and ethical AI practices. The next section details the systematic review methodology we employed to ensure the framework is both rigorous and reflective of the current state of research.

# METHODS

## RESEARCH DESIGN

This study employed SLR as its research design to develop the AI Education Competency Framework. By following established guidelines for systematic reviews (such as PRISMA), we ensure methodological rigor and a comprehensive coverage of relevant literature. The SLR approach was chosen to ground the framework in empirical evidence and theoretical insights from prior studies, thereby strengthening its validity and relevance.

## SEARCH STRATEGY

A broad search strategy was implemented to capture literature across multiple disciplines related to AI in education. We queried multiple academic databases known for extensive coverage of educational technology and AI research, including Google Scholar, PubMed, IEEE Xplore, SpringerLink, and the ACM Digital Library. These databases span fields from education and social sciences to computer science and engineering, ensuring a multidisciplinary perspective. Table 1 lists the databases and their relevance to this review.

**Table 1** Databases searched for literature on AI competency frameworks in education.

| DATABASE | SCOPE AND RELEVANCE |
|---|---|
| Google Scholar | Broad academic search (articles, theses, books, conferences) across disciplines. |
| PubMed | Life sciences and biomedical literature (for AI in medical education contexts). |
| IEEE Xplore | Engineering and technology literature (key for technical AI competency studies). |
| SpringerLink | Multidisciplinary journals and books (for diverse perspectives on AI in education). |
| ACM Digital Library | Computing and IT research (critical for studies on educational AI tools and systems). |

The search included literature published up to early 2024, emphasizing studies from the past 10–15 years due to the rapid evolution of AI. We used a combination of keywords to ensure retrieval of relevant studies covering various facets of AI in education. Key terms included: *"AI framework in education", "AI competency framework education", "artificial intelligence in education", "AI policy in education", "AI learning platform framework",* "AI ethics in education", and *"AI integration in education"*. These terms were applied in different combinations using Boolean operators to cast a wide net. For example, in IEEE Xplore we used queries like ("AI competency" AND education) OR ("AI literacy" AND framework) to capture both competency and literacy discussions. Similarly, Google Scholar was used to identify grey literature or emerging studies (e.g., arXiv preprints) that might not yet be indexed in traditional databases.

This ensured the latest developments in AI and education, including less widely disseminated research, while reducing publication bias and expanding scope coverage.

## INCLUSION AND EXCLUSION CRITERIA

We applied specific inclusion and exclusion criteria to filter the search results to the most relevant and high-quality studies (Table 2). Studies were included if they met these criteria.

**Table 2** Inclusion and exclusion criteria for study selection.

| INCLUSION CRITERIA | EXCLUSION CRITERIA |
|---|---|
| Published in peer-reviewed journals or reputable conferences. | Not available in full text (abstracts without full papers). |
| Focused on AI competency frameworks or AI literacy in educational settings (research articles, reviews, or conceptual papers). | Non-English publications (this review included only English-language studies). |
| Addresses at least one of: theoretical knowledge, practical applications, or ethical considerations of AI in education. | Studies not centered on educational settings (e.g., AI in industry without educational context) or not addressing AI competencies/frameworks. |
| Presents empirical findings, a proposed framework/model, or a systematic review relevant to AI in education. | Articles with minimal relevance to AI education (e.g., using AI to solve a pure computing problem with no education focus). |

These criteria ensured that we captured a range of work, from empirical studies to theoretical frameworks, but remained focused on our topic. We also excluded non-English works to avoid translation uncertainties and because the vast majority of AI-in-education literature is published in English.

## STUDY SELECTION PROCESS

Following the search and initial filtering by titles and abstracts, we proceeded through the PRISMA-based selection process of identification, screening, eligibility, and inclusion:

- **Identification**: The database searches yielded a total of *1,700 records* (approximately 1,500 from databases and 200 from other sources such as reference lists and preprint servers). After removing duplicates (around 300) and non-relevant or automated-flagged entries (around 150 total), *approximately 1,250 unique records* remained for screening.
- **Screening**: We screened these 1,250 records by reading titles and abstracts to assess relevance. At this stage, about 950 records were excluded because they clearly did not meet the inclusion criteria (e.g., off-topic, or lacking any framework/competency focus). This left 300 articles for detailed evaluation.
- **Eligibility**: We sought full-texts for these 300 articles. Fifty could not be retrieved because they were either unavailable through our institutional access, not fully accessible in the databases, or had missing links to the full text. We thoroughly read the remaining 250 full-text articles to evaluate against our criteria. Each article was assessed by at least two researchers for inclusion. We excluded studies that, upon full reading, did not substantially address AI competencies in education or were of insufficient quality (e.g., lacking a clear methodology). Common reasons for exclusion at this stage were: not focusing on an educational AI framework (100 studies), not meeting the eligibility requirement of including empirical or review evidence (50 studies), or other context mismatches (e.g., training industry employees rather than students) (79 studies).
- **Inclusion**: Ultimately, 21 studies were deemed fully relevant and of high quality to be included in the review synthesis. These included a mix of literature reviews, empirical research, and conceptual framework papers that collectively inform the development of our AI Education Competency Framework.

For transparency and replication, a PRISMA flow diagram detailing the selection process is presented in Figure 1.

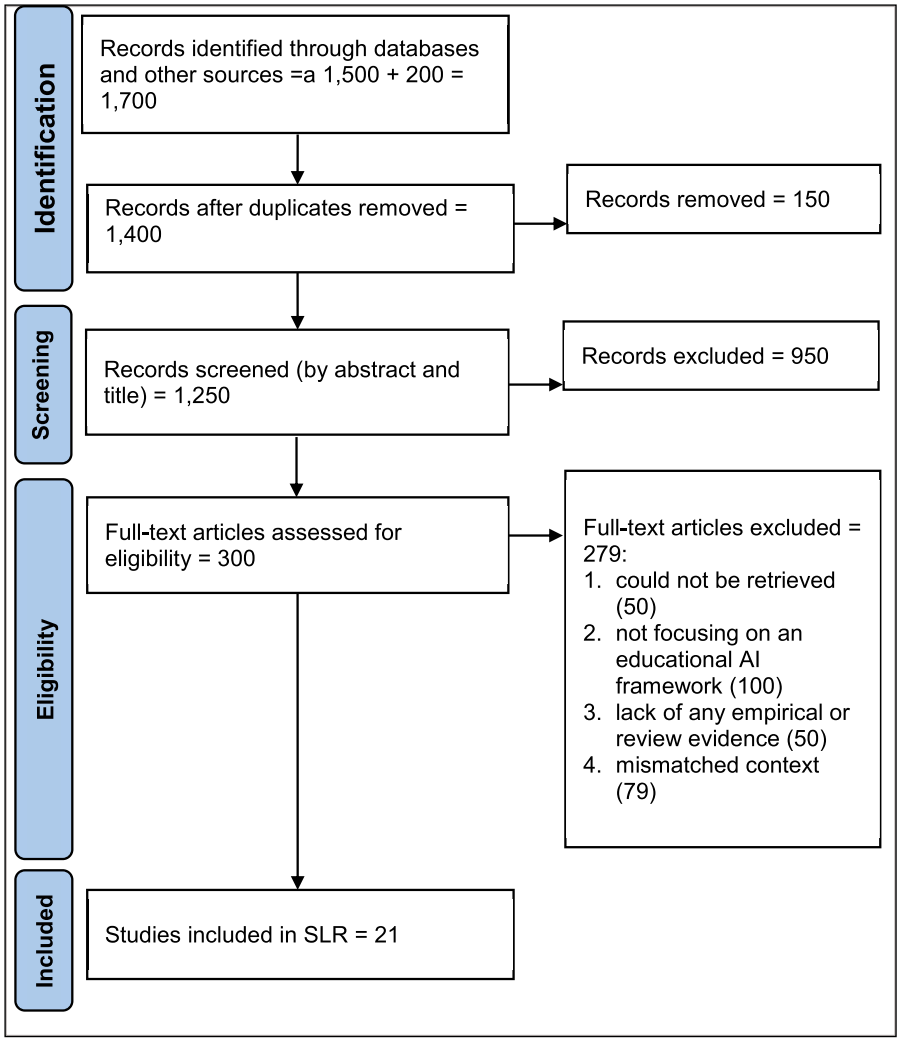


**Figure 1** PRISMA Diagram.

## DATA EXTRACTION AND SYNTHESIS

For each of the 21 included studies, we extracted key information such as: bibliographic details (authors, year, publication), study purpose, methodology, and major findings or propositions related to AI competencies. We paid special attention to any frameworks, models, or competency lists proposed, as well as recommendations and identified gaps. The extraction was organized in a table format to compare insights across studies (see Appendix for a summary of included studies and their contributions).

We then synthesized the data using a thematic approach. As we reviewed the studies, recurring themes and competency domains emerged. For example, several studies emphasized *technical fundamentals and AI literacy* as critical (aligning with what we term the "Foundation" pillar), while others highlighted *curricular integration and teacher training*, *innovation in AI tools*, or *ethical considerations*. We merged and mapped these themes, which resulted in the components and pillars of our framework. This process was iterative: as we identified themes, we revisited the studies to ensure all relevant information was captured and to refine the framework's structure. We also cross-referenced the themes with the gaps identified in the Literature Review. Notably, the four pillars of the framework (Foundation, Integration, Innovation, AI Citizenship) were directly inspired by the clustering of themes from the literature.

Throughout the synthesis, we ensured methodological rigor by having multiple researchers independently validate the themes and included studies. The researchers compared the themes and, through collaborative discussion, reached consensus on the final set of themes and studies, ensuring the conclusions are unbiased and not influenced by individual perspectives. Disagreements or ambiguities in interpreting a study's implications were resolved through discussion, and in some cases by consulting additional sources cited in those studies for clarity. This rigorous approach enhances the validity of the resulting framework, as it is built upon consensus and evidence rather than a single author's interpretation.

In summary, our methodology combined a comprehensive SLR with careful thematic analysis to ensure the AI Education Competency Framework is empirically validated and addresses the multifaceted gaps identified in prior work. The following section presents the framework itself, detailing each of its pillars and components, followed by a discussion of its significance and applications.

## FINDINGS

Drawing on the systematic review findings, we developed the AI Education Competency Framework to guide educational institutions in integrating AI effectively. Each pillar (i.e., Foundation, Integration, Innovation, and AI Citizenship) represents a critical dimension of AI integration in education, and together they form a holistic model. Table 3 provides an overview of the pillars and their focus.

**Table 3** Overview of the AI Education Competency Framework pillars.

| PILLAR | FOCUS AND OBJECTIVES |
|---|---|
| Foundation | Building fundamental AI knowledge and literacy among all stakeholders. Basic competencies include understanding AI concepts, tools, and terminology. |
| Integration | Embedding AI into curricula, pedagogy, and administrative processes. This involves training educators, updating curriculum content to include AI, and implementing AI tools to enhance teaching, learning, and operations. |
| Innovation | Fostering the development and adoption of new AI-driven educational tools, methods, and research. Encourages experimental initiatives like AI labs, pilot projects, and interdisciplinary AI collaborations. |
| AI Citizenship | Ensuring ethical, responsible use of AI and addressing its societal implications. Focuses on competencies in AI ethics, data privacy, fairness, inclusivity, and developing policies for responsible AI deployment. |

Each pillar, with its specific competencies and recommended actions, is described in detail below. The pillars are interrelated; success in AI integration requires progress in all four areas. For instance, ethical AI use (AI Citizenship) is intertwined with how AI tools are integrated and used in practice (Integration), and a strong foundation of AI knowledge is necessary to drive innovation responsibly.

### FOUNDATION

The Foundation pillar addresses the essential question: *How do we ensure educators and learners have the necessary knowledge to engage with AI?* This pillar emerged from numerous studies highlighting fundamental AI knowledge as a prerequisite for effective integration (e.g., Faruqe et al., 2021). Key components of this pillar include:

- **Basic AI Knowledge for Faculty and Students**: Implement introductory courses, workshops, and seminars on AI fundamentals. By building a common understanding of AI technologies, the institution prepares stakeholders to adopt more advanced AI applications. *Activities*: professional development sessions and seminars on AI basics; online modules covering AI terminology, capabilities, and limitations.
- **AI Literacy and Critical Thinking**: Develop resources to improve critical thinking about AI. This means not only knowing *what* AI is, but understanding *how* it works and its implications. Inspired by Long and Magerko (2020)'s competencies, the framework includes training on interpreting AI outputs (e.g., recognizing accuracy limits and potential data biases). *Activities*: interactive tutorials on AI decision-making; discussions on real-world AI case studies to practice critical evaluation.
- **Continuous Learning Culture**: Given the fast pace of AI advancements, this pillar also emphasizes fostering a culture of continuous learning. This could involve setting up learning communities or clubs where students and faculty regularly share new AI developments or tools relevant to their field. *Activities*: AI reading groups; internal newsletters or forum on emerging AI tools for education.

By ensuring a strong foundation, the framework aims to prevent AI initiatives from failing due to limited basic understanding. For example, a faculty member unfamiliar with AI concepts may resist or misuse AI tools in class; the Foundation pillar mitigates this risk by upskilling stakeholders. Initiatives such as the University of Florida's AI curriculum project demonstrate the value of widespread AI literacy as "foundational knowledge essential for global citizenship" (Southworth et al., 2023).

## INTEGRATION

The Integration pillar addresses questions like: *How can AI tools enhance teaching and learning? How do we train educators to use AI? How can AI improve institutional operations?* This pillar bridges the gap between theoretical knowledge and practical application. Its key components include:

- **Curriculum Embedding**: Revise curricula to include AI-related content and competencies. This means not only teaching *about* AI in relevant courses but also using AI tools as part of the teaching process across disciplines. Schleiss et al. (2023) provide a framework for domain-specific AI course design, which can guide such integration by identifying where AI topics fit into existing syllabi. *Activities*: adding AI case studies or mini-projects in non-CS courses; creating interdisciplinary modules (e.g., "AI for Business" in business programs).
- **Faculty and Staff Training**: Implement AI-specific training programs for educators and administrators. Teachers must develop skills in using AI-driven educational software and in interpreting AI-based student analytics. Administrators can be trained to apply AI tools for tasks like admissions, scheduling, or campus management. *Activities*: workshops on using AI educational platforms; certification programs in AI-assisted pedagogy.
- **Pilot Projects and Operations**: Pilot AI implementations across departments help identify best practices and challenges, improving operational efficiency and guiding broader adoption. As literature notes, integrating AI into processes requires careful planning and iteration. *Activities*: small-scale deployments of AI tools (with evaluation); internal grants for departments to experiment with AI solutions.
- **Infrastructure and Support**: Integration also requires technical infrastructure (e.g., adequate computing resources, software platforms) and support mechanisms. Institutions may need to invest in ed-tech infrastructure or partner with technology providers. This pillar also entails providing robust support and addressing technical barriers.

By focusing on integration, the framework ensures that AI moves beyond concept into practice within the institution. Over time, effective integration as envisioned in this pillar leads to AI becoming a natural part of teaching strategies and institutional workflows, rather than a novelty or add-on.

## INNOVATION

The Innovation pillar aims to cultivate an environment where both faculty and students actively engage in creative exploration of AI in education, thus keeping the institution at the forefront of technological advancement. This pillar aligns with calls in the literature for not just using existing AI tools but also contributing to innovation in the field of AI in education (AIED). Key components include:

- **Innovation Labs and Sandboxes**: Establish dedicated spaces (physical or virtual) where educators and learners can experiment with AI technologies. For example, an "AI in Education Lab" could help faculty prototype AI-driven applications with technical support. Such labs embody the experimental spirit in AI education, illustrating how AI can enhance teaching and learning (Holstein et al., 2020) and how explanations influence users' understanding of AI systems (Alipour et al., 2020). *Activities*: hackathons for educational AI, collaborative projects between computer science and education departments.

- **Research and Development**: Encourage faculty-led research into AI-enhanced teaching strategies and learning science, including classroom action research or formal research studies on AI pedagogies. By contributing to research, the institution also gains early insight into the most effective innovations. *Activities*: seed funding for AI-in-education research projects; partnerships with ed-tech companies or other universities on innovative pilots.
- **Student Innovation and Engagement**: Include students in innovation through project-based learning opportunities focused on AI. This not only builds student competencies but can yield fresh, creative solutions. *Activities*: student competitions for AI solutions in education; mentorship programs where students develop AI tools under faculty guidance.
- **Iterative Implementation of New Tools**: Deploy cutting-edge AI tools and refine their use iteratively. This ensures the institution remains adaptive and continuously improves AI integration strategies. *Activities*: pilot new AI-driven tools, collect user feedback, and adjust implementation guidelines.

By fostering innovation, the framework ensures the institution not only uses AI tools but actively shapes their development and application. This pillar future-proofs AI integration by cultivating internal capacity to adapt to new AI trends, such as generative AI models or adaptive learning systems. It aligns with the notion that educational institutions should be "laboratories for AI-driven educational innovation", preparing educators and students to be creators, not just users, in the AI era.

## AI CITIZENSHIP

The AI Citizenship pillar addresses the ethical, social, and human-centered dimensions of AI in education. Its inclusion recognizes that technical integration alone is insufficient; educators and learners must also use AI responsibly and understand its broader impacts, in line with established ethical frameworks and risk considerations. Key components include:

- **Ethical AI Use Protocols**: Develop and disseminate clear policies and guidelines on the ethical use of AI within the institution. This covers issues like data privacy, academic integrity, and fairness and non-discrimination. Frameworks and risk indicators from Holmes et al. (2022) and Li and Gu (2023) can guide these protocols. *Activities*: an institutional AI ethics committee to review and update policies; training sessions on AI ethics for students and staff.
- **Digital Well-being and Inclusion**: Ensure AI tools are designed and implemented with accessibility and inclusivity in mind, such as supporting students with disabilities and reducing digital divides. AI Citizenship means promoting equal access to AI's benefits and being vigilant about its potential to marginalize. *Activities*: accessibility audits for new AI tools; workshops on AI bias and mitigation strategies.
- **Critical Reflection and AI Societal Impact**: Encourage a habit of reflection among students and staff on how AI is affecting society and education. This can be integrated into curricula (e.g., class discussions on the impact of AI on future jobs, or philosophy courses debating AI and consciousness). Chiu et al. (2024)'s emphasis on confidence and self-reflection as part of AI competency is pertinent here. *Activities*: seminars or speaker series on AI in society; reflection journals for students using AI tools.
- **Accountability and Governance**: Establish governance structures for AI use. This could involve procedures for evaluating and approving AI tools before adoption, and mechanisms for stakeholders to report concerns or unintended consequences of AI systems. Ensuring accountability (who is responsible if an AI system errs?) is a part of this pillar. *Activities*: an AI oversight board; periodic reviews of AI systems in use (akin to curriculum reviews).

By integrating AI Citizenship into the framework, we align technology integration with human values and societal needs. This pillar helps prevent scenarios such as uncritical adoption of AI that might infringe on student privacy or relying on AI recommendations without human oversight. It prepares students to be responsible AI users and creators in their future careers, echoing the notion of producing not just skilled graduates, but conscientious digital citizens.

Importantly, it also builds trust within the institution and with external stakeholders (parents, community) that AI is being used thoughtfully and ethically.

### FRAMEWORK SYNTHESIS

Collectively, the four pillars provide a comprehensive competency framework for AI integration in education. Each pillar contributes distinct competencies and organizational practices, but they are designed to reinforce one another. For example, a strong Foundation of AI knowledge enables deeper Integration into curriculum; successful Integration efforts will likely spark new ideas that feed the Innovation pillar; and all three of those pillars must operate under the guidance of AI Citizenship to ensure alignment with ethical standards. Figure 2 illustrates the framework, showing the pillars and their interplay.

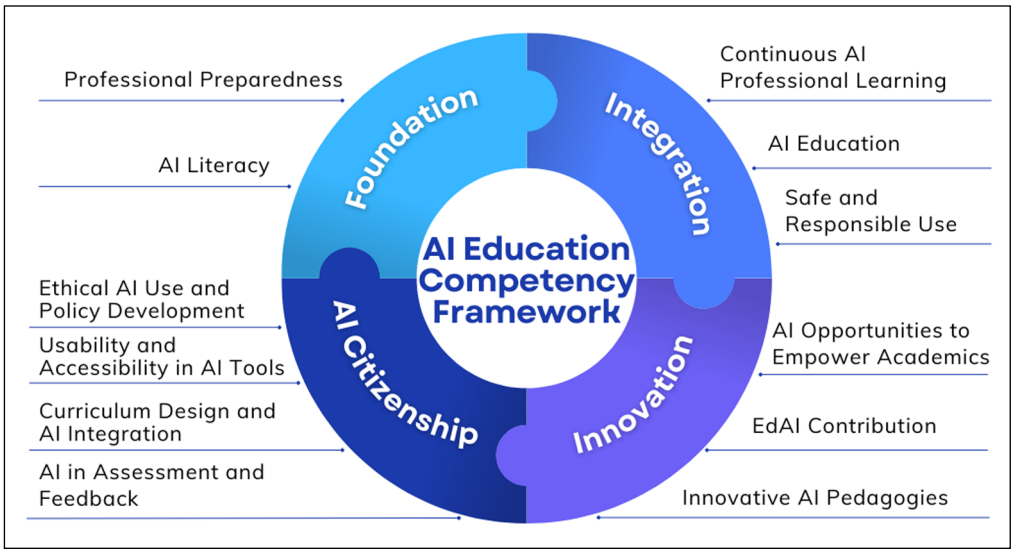


**Figure 2** AI education competence framework.

It is worth noting that the AI Education Competency Framework is scalable and adaptable. Any institution, regardless of context, can use it as a guide to identify which areas of AI readiness need development. For example, what works for a large research university may differ for a small community college or a K-12 school. A high school might focus heavily on the Foundation and AI Citizenship pillars (ensuring students and teachers have basic AI literacy and ethical awareness), whereas a university might invest more in the Innovation pillar (establishing research labs) in addition to the others.

In the next section, we discuss the implications of this framework, how it compares to existing models, and the significant contributions it offers. We also address potential challenges in implementing the framework and provide recommendations to maximize its impact.

## DISCUSSION

The AI Education Competency Framework presented in this study offers a comprehensive and structured approach to integrating AI into educational institutions. In contrast to prior efforts that tackled isolated aspects of AI in education, this framework spans the technical, pedagogical, and ethical dimensions in a single model. This addresses a significant gap identified in the literature: the lack of a cohesive framework that ties together curriculum design, teacher training, continuous learning, and ethical AI use.

### CONTRIBUTIONS TO THEORY AND PRACTICE

The framework's four pillars synthesize a wide range of research insights into an actionable structure. Each pillar contributes to the literature by consolidating themes that were previously scattered:

- **Foundation**: The emphasis on theoretical knowledge base (AI literacy) as fundamental aligns with and extends works like Kim et al. (2021) and Zhou et al. (2020) who stress building AI literacy among educators and students. By incorporating these into a

formal pillar, our framework highlights foundational AI literacy as a strategic priority for institutions, not just a nice-to-have. This pillar's inclusion underscores that any high-impact use of AI in education starts with knowledgeable participants.

- **Integration**: This pillar bridges theory to practice by outlining how to incorporate AI into the day-to-day educational process. Prior studies offered pieces of this puzzle (e.g., Schleiss et al., 2023), on course design), and our framework unifies them. The Integration pillar provides a roadmap for implementation, guiding institutions on training programs and curricular enhancements. It contributes to practice by offering a scalable approach for schools to follow when rolling out AI initiatives, mitigating the risk of piecemeal or fragmented implementation.
- **Innovation**: This pillar encourages pushing boundaries, reflecting the dynamic nature of AI technology. With its inclusion, the framework explicitly values research and creative development in education. This is a novel aspect compared to many competency models, which often focus only on current skills. Our framework, therefore, contributes a forward-looking perspective: institutions should cultivate the ability to evolve with AI advancements. This idea echoes calls for continuous innovation in higher education (Southworth et al., 2023) to keep pace with global AI trends.
- **AI Citizenship**: The most distinguishing feature of our framework is elevating ethical and societal considerations to the level of a core pillar. Many previous works discuss ethics (Holmes et al., 2022; Chiu et al., 2024), but our framework integrates those principles across all competencies. This ensures that discussions of bias, fairness, and responsibility are not adjunct topics but fundamental to the competency set. In practice, this pillar can help institutions proactively address public and stakeholder concerns about AI, thus smoothing the path for AI initiatives by building trust and accountability.

Overall, the framework's holistic approach is a key contribution. It demonstrates that high-impact AI integration in education is not solely a technical endeavor; it is a multifaceted change that involves educating people (Foundation), changing processes (Integration), encouraging creativity (Innovation), and safeguarding values (AI Citizenship). It is worth noting that while these pillars are designed to be complementary, conflicts may still arise. For example, the drive for innovation could at times conflict with ethical and societal considerations in the AI Citizenship pillar. Recognizing such potential conflicts is important for institutions applying the framework. This multi-pronged model is adaptable to various educational contexts and can guide future research to explore not only all these dimensions but also the potential conflicts between them, such as balancing innovation with ethical and societal considerations in AI integration.

## METHODOLOGICAL RIGOR AND VALIDITY

The use of a systematic review to derive the framework adds empirical weight to its components. Rather than being based on a single institution's experience or one researcher's perspective, the framework is grounded in evidence aggregated from 21 studies. This method strengthens its validity: each pillar and action is traceable to documented needs or successful practices in the literature. For example, the emphasis on continuous professional development in the Integration pillar is supported by multiple studies identifying teacher training as essential for AI adoption (e.g., Kim & Kwon, 2023 reported low teacher confidence in AI, underscoring training needs). Similarly, the AI Citizenship pillar is validated by numerous calls for ethical frameworks and risk mitigation strategies (Li & Gu, 2023; Holmes et al., 2022) which we incorporated. This rigorous grounding addresses the methodological gap often pointed out in conceptual papers. Our framework is not merely proposed, but *derived* from systematic analysis.

## IMPLEMENTATION CHALLENGES

A notable challenge in implementing the framework is the varying levels of AI literacy among faculty and students at the start. In institutions where most stakeholders are new to AI, the Foundation pillar can take significant time and resources to establish. However, the framework anticipates this by including targeted training and resources as part of the solution. Another challenge is the potential resistance to change, as integrating AI tools into curricula and

operations may require shifts in teaching practice and institutional policy. This is where strong leadership and a clear phased implementation plan (possibly guided by an AI integration roadmap) are critical. As suggested in our findings and aligned with Schleiss et al. (2023), a phased approach with pilot programs can demonstrate quick wins and build momentum.

Resource constraints can also be a barrier. Not all institutions have the funding for AI labs or extensive training programs. The framework can be scaled to address this: for instance, if establishing an AI innovation lab (Innovation pillar) is not immediately feasible, the institution might begin with smaller innovation activities like collaborative projects or leveraging free AI tools. Additionally, institutions can seek partnerships (with tech companies or through grants) to support resource-intensive aspects.

Ensuring the ethical use of AI (AI Citizenship) presents a continuous challenge as well. It requires ongoing vigilance; policies and training must keep up with emerging ethical issues (e.g., new privacy concerns with evolving AI). Our framework's recommendation of an AI ethics committee or oversight mechanism is intended to address this, but it relies on institutional commitment to sustain such governance.

Despite these challenges, the framework provides a structured way to anticipate and address them. Each pillar comes with its own set of recommendations that, if followed, can mitigate the risks. For example, the Foundation pillar's focus on broad AI literacy helps pre-empt resistance by making stakeholders more comfortable and proficient with AI. The Integration pillar's pilot projects allow ironing out kinks on a small scale before scaling up. The AI Citizenship pillar's protocols can prevent or quickly respond to any ethical missteps, maintaining trust.

## COMPARISON WITH EXISTING FRAMEWORKS

Compared to other AI competency or literacy frameworks, our AI Education Competency Framework is distinctive in its scope and integrative nature. Many existing models, such as those reviewed by Mikeladze et al. (2024), focus on teacher competencies or student skills alone. Our framework bridges both by addressing institutional practices (like curriculum integration) alongside individual competencies. It also explicitly connects to institutional strategy. Few frameworks discuss the need for things like innovation labs or governance committees, as these often fall outside the purview of individual competencies. By doing so, we connect competencies to the environment that nurtures those competencies.

In essence, our framework could serve as a blueprint for institutions to follow, whereas previous frameworks often serve as checklists of skills for individuals. We believe both perspectives are important and complementary. In fact, an institution implementing our framework will naturally enhance individual competencies (e.g., teachers will gain TPACK skills, students will gain AI literacy), achieving the goals of those other frameworks in a supportive context.

The major contributions of this work can be summarized as follows:

- **Holistic AI Integration Model**: We provide one of the first comprehensive frameworks that covers knowledge, application, innovation, and ethics for AI in education in equal measure. This model can guide strategic planning for educational leaders looking to implement AI initiatives.
- **Empirically Informed Framework Design**: By using a systematic review as the basis, we contribute a framework that is evidence-based. This addresses a gap in literature where many proposals are theoretical; our framework is based on multiple studies, giving it credibility and a clear connection to existing research.
- **Identification of Gaps and Future Needs**: In synthesizing the literature, we identified specific gaps, such as the need for longitudinal research on AI in education outcomes and the inconsistency in AI competency definitions. The framework's composition implicitly highlights these. For example, the Innovation pillar encourages generating evidence (through pilots and R&D) that could feed back into long-term studies. We also explicitly recommend future research directions below, thereby contributing a research agenda for the community.

### PRACTICAL GUIDANCE AND RECOMMENDATIONS

Our work goes beyond theory by outlining practical steps and considerations for implementation (further detailed in the recommendations section). This makes the contribution actionable. Educators and administrators can use our results as a guide to audit their current state (e.g., "How are we doing on each of the four pillars?") and plan improvements.

## LIMITATIONS AND FUTURE RESEARCH

### LIMITATIONS

It is important to acknowledge the limitations of this study. First, while the SLR was comprehensive, it may not have captured every relevant study, especially very recent publications or those in languages other than English. There is also an inherent bias in literature towards successful case reports; we found fewer papers discussing failures or negative results of AI integration, which could also offer valuable lessons. Moreover, the framework at this stage is a conceptual model informed by literature; it has not yet been tested as a whole in a single institution. This means that while each element is supported by evidence, the combined impact of implementing the entire framework is an area for future validation.

Another limitation is that the framework may need adaptation for different educational levels (K-12 vs higher education). We have taken a general approach, but specific competencies might differ slightly by context. For example, "AI Citizenship" for young children would be framed differently (more about awareness and basic digital citizenship) compared to graduate students. Despite these limitations, the framework provides a robust starting point. Future work can build on it, testing and refining the framework in practice (e.g., through case studies of implementation in various institutions).

### FUTURE RESEARCH

Building on this framework, future research should explore the long-term impacts of AI integration on educational outcomes. Longitudinal studies could track cohorts of students in AI-rich learning environments versus traditional settings to assess differences in learning, skill development, and career trajectories. Additionally, research should examine the framework's implementation: Which pillars are most challenging in practice? How do institutions sequence the rollout? Such studies will provide feedback to improve the framework. Investigating specific components in depth, such as the best approaches for AI ethics training in education or the most effective ways to foster teacher innovation with AI, would also be valuable.

Another fruitful area is measuring the efficacy of the framework. Developing assessment tools that gauge an institution's maturity in each pillar (akin to a rubric or index for AI integration readiness) could help in both research and practice. These assessments could correlate with outcomes like student performance, teacher satisfaction, or operational efficiency to quantify benefits of moving up the competency framework.

Other than that, future studies can be conducted to explore potential conflicts between the pillars, such as regarding how the drive for innovation might sometimes conflict with ethical or societal responsibilities. Exploring these dynamics would provide a richer understanding of how the framework can be applied in diverse contexts, offering insights into how institutions can navigate conflicts between dimensions while still ensuring effective and responsible AI integration.

Additionally, our proposed framework does not extend to the sustainability and environmental dimensions of AI in education, such as energy consumption and ecological impact. While these concerns are increasingly relevant to ethical and societal considerations, they fall outside the present scope. Future research could expand on this framework by integrating sustainability perspectives to ensure a more holistic understanding of responsible AI use in education.

Lastly, as AI technology evolves (e.g., more advanced AI tutors, widespread adoption of AI assistants like ChatGPT), the framework should be revisited. The pillars are likely to remain relevant, but the specific competencies under each may evolve. Keeping the framework up-to-date will be an ongoing collaborative effort among researchers and practitioners in the field.

## CONCLUSION

AI's transformative potential in education can only be realized if institutions and individuals develop the necessary competencies and infrastructures to use AI effectively. The AI Education Competency Framework we propose provides a strategic, evidence-based roadmap for this journey. By focusing on foundational knowledge, practical integration, innovation, and ethical AI citizenship, the framework ensures that AI adoption in education is balanced and sustainable. It moves the conversation from *"Should we use AI in education?"* to *"How can we integrate AI in a way that maximizes benefits and minimizes risks?"*.

This study makes several significant contributions. The framework itself is a primary contribution, offering a unified model that stakeholders can reference. Additionally, through the systematic review, we reinforced the empirical foundation of AI-in-education research by highlighting key findings, gaps, and trends from the past decade. We showed that while interest in AI is high, strategic competency frameworks have been the missing link—a gap this work aims to fill. We also provided practical recommendations that can guide immediate action in educational settings.

The implications of adopting the AI Education Competency Framework are far-reaching. Educational institutions that embrace this framework position themselves to produce graduates who are not only AI-literate but also capable of innovating with AI and mindful of its societal impacts. Educators become empowered to enhance their teaching with AI, rather than feeling threatened by it. In essence, the framework fosters an AI-ready educational ecosystem: one that can evolve with technological advances and contribute positively to the ongoing AI revolution in society.

As we conclude, we underscore the importance of viewing AI integration as a multidimensional endeavor. Success lies in coupling technical adoption with human capacity building and ethical safeguards. The AI Education Competency Framework encapsulates this philosophy. We also acknowledge the debates around the competency frameworks in education, such as regarding the risk of oversimplifying complex learning or imposing rigid structures. However, we position our framework as a flexible guide, rather than a prescriptive checklist, designed to be adapted across diverse contexts while encouraging critical reflection and continuous refinement. We encourage educational leaders, policymakers, and researchers to use, test, and refine this framework. Through collaborative efforts, the education sector can harness AI in a high-impact manner, ultimately enriching learning experiences and outcomes for students while upholding the values that are central to education.

### RECOMMENDATIONS FOR IMPLEMENTATION

To operationalize the insights from this study, we offer the following practical recommendations aligned with the framework's pillars:

1. **Invest in AI Literacy for All**: Begin with campus-wide AI literacy initiatives. Offer workshops and create accessible learning materials so that every teacher, student, and staff member gain a basic understanding of AI concepts and tools (Foundation pillar).
2. **Integrate AI Tools Gradually into Curriculum and Operations**: Identify a few pilot courses and administrative processes where AI can add value, and integrate tools there first (Integration pillar). Provide support and gather feedback during these pilots.
3. **Encourage and Reward Innovation**: Set up mechanisms such as innovation grants or an AI lab where educators and students can experiment with AI in teaching and learning (Innovation pillar). Recognize and reward successful innovations to build momentum and buy-in for AI initiatives.
4. **Establish Ethical Guidelines and Oversight**: Formulate clear guidelines on acceptable AI use and create an oversight committee to review AI implementations (AI Citizenship pillar). Include diverse stakeholders in this committee to ensure broad perspective and trust.

By following these recommendations, institutions can make tangible progress on each pillar of the framework. The journey to AI integration in education is iterative and continuous, but with

a competent framework and careful planning, institutions can lead the way in leveraging AI for high-impact educational outcomes.

## DATA ACCESSIBILITY STATEMENT

All data generated or analysed during this study are included in this published article [and its supplementary information files].

## SUSTAINABLE DEVELOPMENT GOALS (SDGs)

This study is linked to the following SDG(s): Quality education (SDG 4), Decent work and economic growth (SDG 8), Industry, innovation and infrastructure (SDG 9), and Partnerships for the goals (SDG 17).

## ADDITIONAL FILE

The additional file for this article can be found as follows:

- **Appendix.** Summary of Included Studies. DOI: https://doi.org/10.55982/openpraxis.17.4.1012.s1

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The authors have no competing interests to declare.

## AUTHOR CONTRIBUTIONS (CRediT)

Malissa Maria Mahmud: Conceptualization, coordination of the research process, writing—original draft preparation; Wali Khan Monib: Literature review, data extraction, analysis; Atika Qazi: Literature review, data extraction, analysis; Shiau Foong Wong: Review of selected articles, validation of findings, writing—review and editing; Chandra Reka Ramachandiran: Writing—review and editing; Siti Norbaya Azizan: Validation of findings, writing—review and editing. All authors have read and approved the final version of the manuscript.

## AUTHOR AFFILIATIONS

**Malissa Maria Mahmud** orcid.org/0000-0001-6702-155X
Sunway University, Malaysia

**Wali Khan Monib** orcid.org/0000-0002-9575-9305
Universiti Brunei Darussalam, Brunei

**Atika Qazi** orcid.org/0000-0002-3565-6355
Universiti Brunei Darussalam, Brunei

**Shiau Foong Wong** orcid.org/0000-0002-3252-8163
Sunway University, Malaysia

**Chandra Reka Ramachandiran** orcid.org/0000-0001-7230-5039
Xiamen University, Malaysia

**Siti Norbaya Azizan** orcid.org/0000-0001-9434-3378
Sunway University, Malaysia

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