



PAPER

Curriculum-embedded AI literacy: a mixed-method study of framework implementation in undergraduate management education

Lillian N. Schofield^a , Xue Zhou^b , Georgy Petrov^a , and Andrew Woon^c 

^aQueen Mary University London, UK, ^bUniversity of Leicester, UK, ^cMonash University, Malaysia

ABSTRACT

This paper reports findings from a mixed-methods study examining the integration of Generative Artificial Intelligence (GenAI) literacy within an undergraduate Business Management programme. Drawing on Zhou and Schofield's (2024) AI literacy framework, AI-integrated learning activities were embedded across each year of study to support four dimensions of AI literacy: 'Know and Understand', 'Use and Apply', 'Evaluate and Create', and 'AI Ethics'. Data collected through surveys and focus groups suggest that students perceived curriculum-embedded AI activities as supporting AI literacy development; however, outcomes varied. Year 1 students reported the strongest development in the Know and Understand dimension, while Year 2 students demonstrated greater development in Use and Apply, and in Evaluate and Create. Year 3 students continued to emphasise foundational understanding, highlighting the need for greater scaffolding of advanced competencies. Engagement with AI Ethics remained comparatively limited. The study demonstrates the importance of a strategic, curriculum-wide approach to AI literacy development.

KEYWORDS: AI literacy, AI competencies, curriculum integration, generative artificial intelligence, business education.

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Introduction

Artificial Intelligence (AI) literacy has received increasing attention within higher education (HE); however, there remains no universally accepted definition of the concept. Institutions and educators continue to conceptualise and implement AI literacy in diverse and often inconsistent ways. Current applications include supporting academic writing through brainstorming, drafting, and editing (Jarrah et al., 2023; Wang, 2025); providing personalised feedback and learning support (Song & Song, 2023); facilitating content creation (Rawas, 2024); and streamlining writing tasks such as improving structure, refining grammar, and generating draft content (Huang & Tan, 2023).

Despite growing interest in AI-enhanced learning, research examining the effective use of AI tools within the humanities and social sciences remains limited, particularly in disciplines where critical thinking, interpretation, communication, and reflective judgement are central (Yang et al., 2024). Southworth et al. (2023) argue that AI literacy initiatives have predominantly focused on STEM disciplines, creating a gap in both the development and application of AI literacy within other subject areas. Similarly, Essien et al. (2024) found that business students often engage with AI tools at a relatively superficial level unless their use is supported through structured and reflective pedagogical approaches. While emerging frameworks demonstrate how AI literacy can be embedded across disciplines (Zhou & Schofield, 2024), there remains a limited understanding of how AI literacy can be systematically integrated at programme level.

In this study, GenAI literacy is understood as a multidimensional capability encompassing conceptual understanding, practical application, critical evaluation, and ethical awareness. Drawing on Zhou and Schofield's (2024) framework, this study examines how programme-level integration of AI supports the development of AI literacy across different stages of undergraduate study. Specifically, it investigates students' perceptions of how AI-enhanced learning activities support AI-literacy development.

The study addresses three research questions:

1. How do students perceive the contribution of curriculum-embedded AI activities to the development of AI literacy?
2. How does the development of AI literacy influence students' learning experiences and the development of transferable skills?



3. What additional support mechanisms do students identify as necessary for developing their AI literacy?

The findings contribute to the emerging literature on AI literacy in HE by providing empirical evidence of how curriculum-embedded AI activities influence students' development across different dimensions of AI literacy.

AI literacy and curriculum integration

Artificial Intelligence literacy is increasingly conceptualised as a multidimensional capability that enables individuals to understand, use, critically evaluate, and engage ethically with AI technologies across educational, professional, and societal contexts. Existing definitions converge around four core elements: foundational knowledge of AI concepts and systems, the practical ability to use AI tools effectively, the capacity to critically evaluate AI-generated outputs and their limitations, and awareness of the ethical and societal implications of AI use (Laupichler et al., 2022; Ng et al., 2023; Southworth et al., 2023; Sperling et al., 2024). Beyond technical competence, AI literacy also requires learners to interrogate the assumptions, biases, and consequences embedded within AI systems and to engage with them in reflective and responsible ways (Lodge et al., 2023). This broader conceptualisation positions AI literacy as an essential 21st century competency that supports informed, critical, and ethical participation in increasingly AI-mediated environments. The growing adoption of GenAI within HE has intensified calls for structured approaches to AI-literacy development. While AI technologies can support activities such as information processing, content creation, feedback generation, and problem-solving, meaningful engagement with AI requires students to move beyond functional use towards critical evaluation and responsible application (Cukurova, 2024). Research suggests that effective AI-literacy development depends on intentional curriculum design, educator readiness, authentic learning opportunities, and equitable access to AI technologies (Kong et al., 2024; Rasul et al., 2023; Zhou & Schofield, 2023). Furthermore, students benefit from learning experiences that progressively support movement from foundational understanding towards more independent, evaluative, and reflective engagement with AI (Kong et al., 2024; Laupichler et al., 2022).

To examine AI literacy within this context, this study adopts Zhou and Schofield's (2024) AI literacy framework as its theoretical lens. Building on earlier work by Ng et al. (2023), the



framework conceptualises AI literacy through four interrelated dimensions: Know and Understand AI, Use and Apply AI, Evaluate and Create with AI, and AI Ethics. The 'Know and Understand' dimension focuses on foundational awareness of AI technologies and their capabilities. 'Use and Apply AI' relates to the practical application of AI tools to support learning and problem-solving. 'Evaluate and Create with AI' emphasises the critical assessment of AI-generated outputs and the use of AI to support the creation of new ideas and artefacts. Finally, 'AI Ethics' functions as a cross-cutting dimension concerned with responsible, transparent, and ethical AI use. The framework broadly aligns with the progression described within Bloom's taxonomy (Bloom et al., 1956), whereby learners move from foundational knowledge and application towards higher-order processes such as evaluation and creation. However, Zhou and Schofield (2024) emphasise that AI-literacy development is not necessarily linear, as students may demonstrate competence in using AI tools without fully understanding their underlying assumptions, limitations, or ethical implications. Consequently, the framework highlights the importance of developing conceptual understanding, practical capability, critical evaluation, and ethical awareness concurrently. The framework was selected because it provides a practical and pedagogically relevant structure for embedding AI literacy within HE curricula. In this study, it informed both the design of curriculum-embedded AI activities across three levels of undergraduate study and the analysis of students' perceptions of AI-literacy development. Table 1 presents the four dimensions of the framework adopted in this study (Zhou & Schofield, 2024).

Table 1. AI in teaching and learning framework (Zhou & Schofield, 2024).

AI literacy dimension	Students should be able to:	Indicative learning activities
Know and understand AI	Explain basic AI concepts, recognise common limitations, understand the institution's AI-use taxonomy, and experiment with available or approved AI tools relevant to discipline.	AI induction; explore the institutional taxonomy; discipline AI applications, brainstorm with the permitted tools; note-taking.
Use and apply AI	Select and use appropriate AI tools to support learning and disciplinary tasks.	Use AI for research, problem-solving, data analysis, idea development, content creation, agent development or discipline-specific tasks.



Evaluate and create with AI	Critically evaluate AI outputs and use them to develop, refine or create work.	Verify claims and sources; identify errors or bias; compare outputs; justify revisions and final decisions. Co-create with AI.
AI ethics (AI ethics should operate across all dimensions rather than being treated solely as a final stage).	Make responsible decisions about when, how and whether AI should be used.	Follow assessment guidance; disclose AI use; protect data and intellectual property; consider bias, equity and wider impacts. Be able to understand the limitations of AI and use it ethically and responsibly.

In this study, GenAI refers specifically to the generative AI technologies and tools used within the curriculum, whereas AI literacy refers to the broader set of knowledge, skills, critical evaluative capabilities, and ethical awareness required to engage effectively and responsibly with AI. Accordingly, the term GenAI is used when referring to the technologies and associated learning activities, while AI literacy is used when referring to the competencies examined through the adopted framework.

Methodology

This study embedded AI literacy across the BSc Business Management curriculum from Year 1 to Year 3, with progression operationalised through increasing complexity in learning activities, assessment tasks, and expected levels of student autonomy. Although the study does not claim to provide a formal longitudinal measure of AI literacy development, the cross-sectional design captures differences in students reported AI literacy across three year groups within a single academic year, with curriculum activities designed to increase in complexity from foundational understanding and guided use in Year 1 to more independent, critical, and evaluative engagement with GenAI in later years. AI-related pedagogies were integrated into three compulsory modules, each aligned with the intended AI-literacy dimensions and learning outcomes for the relevant stage of study.

At Level 4 (Year 1), GenAI activities were embedded within the module Challenges in Business and Management to develop students' foundational understanding of AI technologies. Students engaged with freely available tools, such as Microsoft Copilot, selected for their accessibility and ease of use across a diverse student cohort. Supported by structured



guidance from instructors, students applied these tools to learning activities including note-taking, presentation development, brainstorming, and content summarisation.

At Level 5 (Year 2), AI integration was extended within the module Working with Business Data, with learning activities designed to support more applied and analytical uses of GenAI. Students utilised both university-licensed and open-access tools, including Microsoft Copilot, Power BI, Bricks, and Julius, to support data analysis, visualisation, and interpretation. Particular emphasis was placed on developing critical and evaluative skills, with tutors supporting students in identifying potential biases, inaccuracies, and limitations in GenAI-generated outputs. This approach reinforced both technical proficiency and ethical awareness.

At Level 6 (Year 3), the module Strategic Analysis and Practice incorporated AI activities designed to support higher-order cognitive processes, including application, evaluation, and co-creation. Students collaborated with GenAI tools to develop strategic analyses within interactive business simulations, requiring them to generate and refine AI-assisted outputs while critically reflecting on their validity, limitations, and ethical implications.

Data collection and participants

A mixed-methods approach was adopted to examine the impact of curriculum-embedded AI activities on students' AI-literacy development and to explore the extent to which learning activities aligned with the intended AI-literacy dimensions at each stage of study. Data were collected through a structured survey administered to 127 undergraduate students. The survey gathered both quantitative and qualitative data relating to: (1) students' perceptions of the contribution of curriculum-embedded AI activities to their development across the four AI literacy dimensions (Know and Understand AI, Use and Apply AI, Evaluate and Create with AI, and AI Ethics); (2) students' perceptions of how AI literacy influenced their learning experiences and the development of transferable skills; and (3) the additional support students identified as necessary for developing their AI literacy.

To complement the survey findings, qualitative data were collected through four focus groups involving a total of 15 students. One focus group was conducted with Year 1 students, two with Year 2 students, and one with Year 3 students. The focus groups explored students' experiences of AI-integrated learning activities, perceptions of their AI literacy development,



and views regarding the support required to engage effectively and responsibly with AI technologies.

Survey instrument

The survey instrument was informed by Zhou and Schofield's (2024) AI literacy framework and designed to capture students' perceptions of AI-literacy development following participation in curriculum-embedded AI activities. The survey consisted of closed-ended Likert-scale items and open-ended questions. Closed-ended items were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), while open-ended questions enabled students to elaborate on their experiences of using AI within the module. In addition to framework-specific questions, the survey explored students' overall experiences of using GenAI in their studies, perceived impacts on learning and transferable skill development, and areas where additional support would be beneficial.

Data analysis

Quantitative survey data were analysed using descriptive statistics to identify patterns in students' reported AI use, perceived AI-literacy development, and learning experiences across the programme. Descriptive measures, including frequencies, percentages, and mean scores, were used to examine variation across the four dimensions of the AI literacy framework. Qualitative data from the focus groups and open-ended survey responses were analysed using a thematic analysis approach (Braun & Clarke, 2006). Findings from the survey and focus groups were then triangulated to provide a richer and more comprehensive understanding of students' experiences of curriculum-embedded AI activities.

Ethical considerations

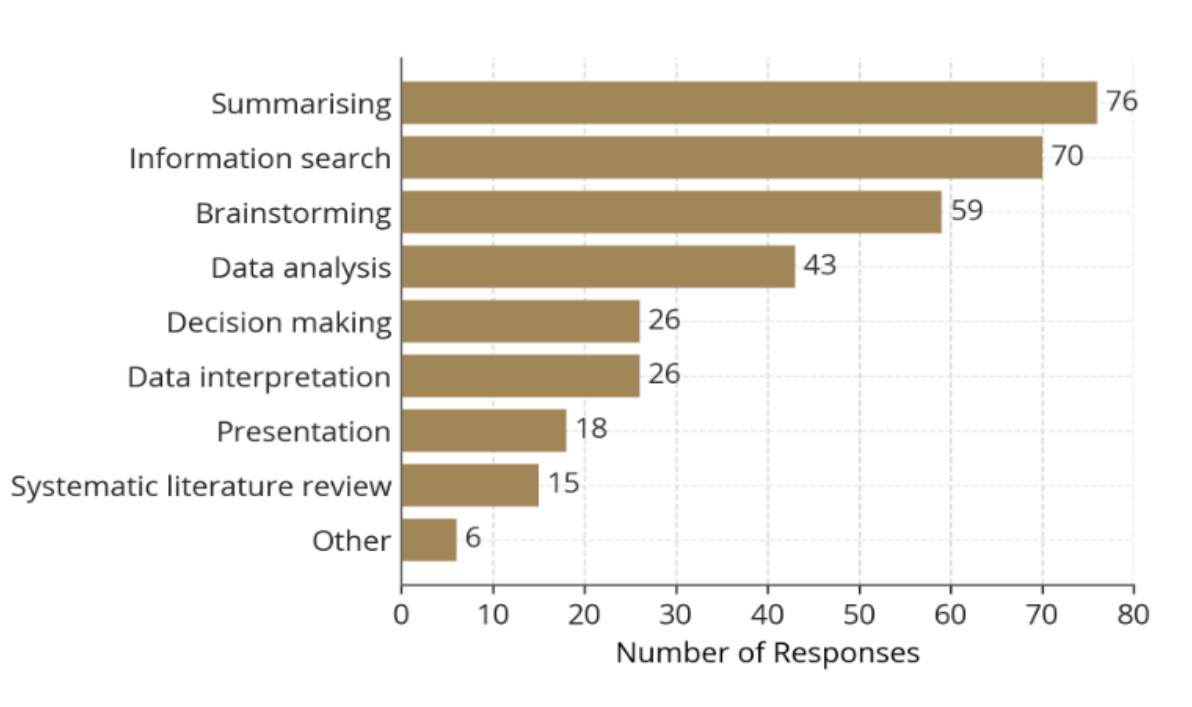
Ethical approval for this study was obtained through the appropriate institutional research ethics review process at Queen Mary University of London (Reference Number: DSREC87). Participation in both the survey and focus groups was voluntary. All participants received information regarding the purpose of the study and provided informed consent before participation. Survey responses and focus-group data were anonymised before analysis, and all data were stored and managed in accordance with institutional data protection and research ethics guidelines.



Results

The findings indicate that students use GenAI in a variety of ways to support their academic work. The most frequently reported use was summarising information, identified by 59.8% of respondents ($n = 76$), followed by information searching (55.1%; $n = 70$). Brainstorming (46.5%; $n = 59$) and data analysis (33.9%; $n = 43$) were also commonly reported, suggesting that students use GenAI to support both creative and analytical tasks. Less frequently reported uses included presentation preparation (14.2%; $n = 18$) and systematic literature reviews (11.8%; $n = 15$).

Figure 1. Students' use of GenAI.



The focus-group findings provide further insight into how students use GenAI in their studies. Several participants described using AI to support understanding and idea generation. For example, one student noted, 'I use AI mostly to summarise information because sometimes there is too much to read, and it helps me understand the key points more quickly' (S11).

Similarly, another participant highlighted the value of GenAI for brainstorming and developing initial ideas, 'We used AI to create ideas for our business simulation ... it was really useful to get inspiration, even if we didn't use everything directly' (S3).

Open-ended survey responses identified additional uses of GenAI, including grammar correction, paraphrasing, understanding complex concepts, and structuring written

assignments. Collectively, these findings suggest that students primarily use GenAI to support information processing, idea generation, and academic task completion.

RQ1: Students' use of GenAI and perceived AI literacy development

The findings indicate variation in the development of AI literacy across the four dimensions of the framework (Know and Understand AI, Use and Apply AI, Evaluate and Create with AI, and AI Ethics) and across different levels of study.

In the Year 1 module, which focused on developing foundational AI literacy, most students reported development within the 'Know and Understand AI' dimension (71.6%). Lower levels of development were reported for 'Use and Apply AI' (18.52%) and 'Evaluate and Create with AI' (4.94%), reflecting the introductory nature of the module and its emphasis on building students' awareness and understanding of AI technologies.

In the Year 2 module, students reported stronger development in the 'Use and Apply AI' (27.78%) and 'Evaluate and Create with AI' (38.89%) dimensions. Focus-group participants described using AI to support data analysis, interpretation, and validation of findings. For example, one student noted, 'We had to use AI to explain the relationships between variables ... it made my understanding deeper' (S7).

Similarly, another student commented, 'We had to double-check our responses with AI ... it was actually the same as what we did manually, so that was quite useful' (S2).

In the Year 3 module, which incorporated GenAI within strategic analysis and simulation activities, most students reported development within the 'Know and Understand AI' dimension (64.29%), while fewer identified development within 'Evaluate and Create with AI' (10.71%). As one student explained, 'We used AI for creating our company logo and doing some analysis in the simulation, but I wouldn't say it helped me develop critical thinking or decision-making ... it was more just to speed things up' (S3).

Across all three modules, the 'AI Ethics' dimension recorded the lowest levels of reported development, ranging from 4.94% to 11.11%. Survey findings further indicate that students generally perceived AI literacy as having a positive impact on their learning experiences and the development of transferable skills. The highest-rated statement, 'I find GenAI useful in my



studies', received a mean score of 4.05 out of 5. One focus-group participant reflected, 'I definitely feel a bit more confident in using AI now ... I can use it to my advantage' (S11).

RQ2: How does the development of AI literacy influence students' learning experiences and the development of transferable skills?

Students also reported relatively high levels of confidence in using GenAI tools (4.00), although some continued to experience difficulties with specific applications (3.63). Focus-group discussions highlighted challenges associated with learning how to use unfamiliar tools effectively. For example, 'It was a bit difficult to understand how to use Copilot effectively in the forecasting task at first ... maybe a bit more training would've helped' (S7).

Similarly, another student noted, 'At first, I didn't know what Bricks or Julius were ... it took me a while to understand how to use them' (S1).

Students also reported engaging critically with GenAI-generated outputs. Relatively high scores were recorded for questioning GenAI-generated responses (3.83), evaluating evidence (3.97), and using AI to support original thinking (3.94). As one participant observed, 'It helps a lot, but only if you know how to check if the answer makes sense' (S7).

The findings further suggest that GenAI supported several transferable skills. Students reported using AI to generate ideas, explore alternatives, and support creative thinking (3.81–3.94). One participant commented, 'We used AI to create ideas for our business simulation ... it was really useful to get inspiration, even if we didn't use everything directly' (S3).

However, lower scores were recorded for systematic approaches to problem-solving (1.26–1.39) and proactive planning (1.39). Reflecting this, one student stated, 'I used it to get started, but I still struggled with organising my time' (S11).

Overall, the findings suggest that students perceive GenAI as supporting learning efficiency, confidence, critical engagement, and creativity, while some areas of skill development, particularly planning and structured problem-solving, remain less evident.

RQ3: What additional support mechanisms do students identify as necessary for developing their AI literacy?

Analysis of survey comments and focus-group discussions identified four main areas where students felt additional support would enhance their AI-literacy development: prompt



engineering, evaluating the accuracy and reliability of AI outputs, technical integration of GenAI tools, and clearer guidance on appropriate AI use.

1. Prompt engineering guidance.

Students frequently highlighted the importance of learning how to formulate effective prompts. Several participants indicated a need for more structured guidance on prompt engineering to improve the quality of GenAI-generated outputs. For example, one student suggested the need for 'AI education on better prompts' (S12).

Similarly, another student reflected, 'One of the most important things that I learned is how to properly formulate prompts ... using correct prompts to generate graphs and tables ... was really useful' (S3).

A further participant noted, 'The teacher explained how to give the correct prompts to receive the correct answers ... the answers became correct after we changed the prompt' (S5).

2. Accuracy and reliability of AI outputs

Students also expressed concerns regarding the reliability and accuracy of AI-generated information. Several participants acknowledged that AI tools can occasionally produce inaccurate or misleading outputs. For example, one student stated, 'I got one answer from GenAI that didn't make sense at all ... but I wasn't sure if it was wrong or if I just didn't understand it properly' (S4).

Another participant observed, 'We had to double-check our responses with AI ... and it was actually the same answer as we did manually, so that was quite useful' (S1).

These comments suggest that students recognise the importance of verifying and critically evaluating GenAI-generated content.

3. Enhanced technical integration

Participants also identified a need for improved technical integration and support for using GenAI tools in combination with traditional software such as Excel. One student commented, 'The Copilot is not always reliable, especially with data visualisation; my friends used ChatGPT, which is much better' (S11).



Another suggested, 'Maybe in the beginning we could have had a demo on how to use each tool ... that would have helped a lot' (S2).

These comments indicate a desire for earlier exposure to GenAI tools and more structured support in integrating them into subject-specific learning activities.

4. Structured training and clearer guidance

Students highlighted the need for more structured training on the effective use of GenAI in academic contexts. Several participants also expressed uncertainty regarding appropriate AI use within assessments. One student noted, 'Sometimes I wasn't sure if we were supposed to say we used AI or if we were allowed to use it for everything' (S3).

Similarly, another remarked, 'There were a lot of conversations about what is allowed in terms of AI and what's not, and I think some of us were still confused' (S14).

A further participant suggested that students should be 'not penalised for using GenAI'.

Collectively, these findings indicate a need for clearer guidance regarding acceptable GenAI use, academic integrity, and responsible engagement with AI technologies within HE.

Discussion

RQ1: To what extent do curriculum-embedded AI activities enhance students' AI literacy across the identified dimensions?

The findings indicate that curriculum-embedded AI activities can support the development of AI literacy across the four dimensions of Zhou and Schofield's (2024) framework. However, this development was not uniform across dimensions or levels of study. Consistent with research emphasising the importance of scaffolded AI-literacy development (Kong et al., 2024; Zhou & Schofield, 2024), students demonstrated different patterns of engagement depending on the pedagogical focus of each module and the intended AI-literacy competencies associated with that stage of study.

In Year 1, students primarily reported development within the 'Know and Understand' dimension. This finding is consistent with the module's focus on introducing foundational AI concepts and familiarising students with GenAI tools. Students predominantly used AI for activities such as summarising information, brainstorming ideas, and supporting presentation



preparation. These activities align with the lower levels of Bloom's taxonomy and reflect the role of AI in supporting knowledge acquisition and comprehension.

By Year 2, students reported stronger development within the 'Use and Apply' and 'Evaluate and Create' dimensions. The integration of AI into data analysis, interpretation, and visualisation tasks appears to have encouraged students to move beyond functional use towards more critical engagement with AI-generated outputs. The requirement to compare AI-generated analyses with manual approaches may have been particularly important in fostering evaluative judgement and reflective practice. This supports Cukurova's (2024) argument that GenAI can enhance learning when students are encouraged to critically interrogate outputs rather than accept them uncritically.

The findings from Year 3 present a more nuanced picture. Although activities were designed to support higher-order AI-literacy capabilities, most students continued to report development primarily within the 'Know and Understand' dimension. This suggests that exposure to AI tools, even within advanced modules, may be insufficient to promote progression towards evaluative and creative engagement. As reflected in students' comments, AI was often used to accelerate task completion rather than to challenge assumptions, evaluate alternative perspectives, or support complex decision-making. This finding aligns with Essien et al. (2024), who found that while AI tools effectively support lower-order cognitive processes, additional pedagogical scaffolding is required to promote evaluation, creation, and critical judgement. One explanation may be that the existing learning activities did not require students to engage with GenAI-supported outputs at an appropriate level of complexity.

A further finding concerns the relatively low levels of reported development within the 'AI Ethics' dimension across all three modules. Although ethical considerations were embedded within learning activities, students rarely identified ethics as a significant aspect of their learning. This suggests that ethical awareness may remain implicit unless it is explicitly foregrounded within curriculum design. As Miao et al. (2024) argue, responsible AI use requires more than technical competence; students must also understand issues such as bias, transparency, hallucinations, accountability, and the limitations of GenAI-generated knowledge. Developing awareness of these challenges enables students to make informed academic judgements and to think critically about when, where, and how GenAI can



meaningfully augment learning while maintaining originality, critical thinking, and academic integrity.

RQ2: How does the development of AI literacy influence students' learning experiences and the development of transferable skills?

The findings indicate that AI literacy can positively influence students' learning experiences and contribute to the development of a range of transferable skills. Students consistently reported that GenAI enhanced productivity, supported knowledge acquisition, and increased confidence in completing academic tasks. These findings are consistent with previous studies highlighting the capacity of GenAI to support routine cognitive activities and reduce the effort associated with information processing and content generation (Zhou et al., 2024).

Beyond efficiency gains, the findings suggest that AI literacy can support higher-order learning processes. Students reported actively questioning AI-generated outputs, evaluating evidence, and using GenAI-generated responses as a starting point for developing their own ideas. Such behaviours indicate movement beyond passive consumption towards more critical and reflective engagement with GenAI. This finding supports research by Kasneci et al. (2023) and Essien et al. (2024), which argues that AI literacy contributes to the development of critical thinking, evaluative reasoning, and self-regulated learning.

The findings also demonstrate that AI-literacy development extends beyond technical competence. Students appeared increasingly capable of selecting appropriate AI tools, adapting prompting strategies, and evaluating the suitability of GenAI-generated outputs for different academic tasks. Such behaviours may indicate increasing confidence in selecting and evaluating AI tools, both of which are increasingly important in AI-mediated learning environments. From a constructivist perspective (Adams, 2006; Vygotsky, 1978), these findings suggest that students develop AI literacy most effectively when they actively engage with, challenge, and reflect upon GenAI-generated content rather than simply consuming it.

However, the findings also reveal important limitations. While GenAI supported idea generation and creativity, its contribution to more systematic problem-solving and proactive planning was less evident. This suggests that although GenAI can enhance certain aspects of learning, its educational value depends on how it is integrated into learning activities and the extent to which students are supported in using it strategically.



RQ3: What additional support mechanisms do students identify as necessary for developing their AI literacy?

The findings highlight the importance of structured and contextualised support for AI-literacy development. Although students demonstrated growing confidence in using GenAI, they consistently identified four areas where additional support would be beneficial: prompt engineering, evaluation of AI-generated outputs, technical integration of AI tools, and clearer guidance regarding responsible AI use.

The prominence of prompt engineering within students' responses suggests that effective interaction with AI should be viewed as a core component of AI literacy rather than a peripheral technical skill. Students recognised that the quality of GenAI outputs was heavily influenced by the quality of prompts, yet many lacked confidence in constructing effective prompts independently. This finding reinforces recent calls for prompt engineering to be explicitly incorporated into AI-literacy curricula (Lodge et al., 2023).

Students also expressed concerns regarding the reliability and accuracy of GenAI-generated information. Their comments demonstrate an awareness that AI outputs require verification and critical evaluation, supporting arguments that AI literacy should include fact-checking, source evaluation, and critical reasoning skills alongside technical competencies. Importantly, students were not requesting unrestricted access to AI but rather greater support in understanding its limitations and using it responsibly.

Finally, uncertainty regarding acceptable GenAI use highlights the importance of clear institutional and programme-level guidance. Several students reported confusion regarding academic integrity, attribution, and appropriate use of GenAI within assessments. In the absence of clear guidance, students may become reluctant to engage with AI or uncertain about how to do so responsibly. Developing consistent policies, examples of acceptable use, and opportunities for discussion may therefore be essential components of future AI-literacy initiatives.

Theoretical implications

This study contributes to the emerging literature on AI literacy in three important ways. First, it advances understanding of how AI literacy can be embedded at programme level rather than through isolated interventions or discipline-specific applications. While much of the existing literature focuses on individual modules or STEM contexts, this study provides insight into how AI literacy may be integrated across multiple stages of an undergraduate programme. The findings support the conceptualisation of AI literacy as a curriculum-wide competency that develops through scaffolded learning experiences rather than as a stand-alone skill.

Second, the study extends existing AI literacy frameworks by demonstrating how the dimensions proposed by Ng et al. (2003) and Zhou and Schofield (2024)—Know and Understand AI, Use and Apply AI, Evaluate and Create with AI, and AI Ethics—can be operationalised within formal curriculum structures. By examining their implementation across three compulsory modules, the study provides insight into how AI literacy frameworks can move from conceptual models to practical educational applications.

Third, the findings contribute to the growing discourse on instructional design in AI education. Drawing on Bloom's taxonomy and constructivist learning theory, the study demonstrates that pedagogical scaffolding plays a critical role in AI literacy development. Students are more likely to progress towards higher-order engagement with AI when learning activities are intentionally sequenced and aligned with increasing levels of autonomy, critical evaluation, and reflection. These findings provide empirical support for the argument that effective AI-literacy development depends not only on access to AI tools but also on how those tools are pedagogically integrated within the learning experience.

Practical implications

The findings have important implications for educators, curriculum designers, and HE institutions seeking to integrate AI literacy within academic programmes. For educators and curriculum designers, the study highlights the importance of embedding AI literacy within core curricula rather than treating AI as an optional or supplementary topic. Students appear to benefit most when AI-related activities are scaffolded across levels of study and aligned with intended learning outcomes. Effective curriculum design should therefore move beyond



introducing AI tools and instead focus on supporting progression from understanding and application to critical evaluation and ethical reflection.

For institutions, the findings emphasise the need for coordinated approaches to AI-literacy development. Students identified prompt engineering, critical evaluation of AI outputs, and responsible AI use as areas requiring additional support. Institutions should therefore consider providing structured training opportunities, guidance on effective AI use, staff development initiatives, and clear policy frameworks to ensure consistency across programmes and disciplines.

Finally, the study highlights the importance of supporting students to engage with AI critically and responsibly. AI literacy should be viewed not simply as technical proficiency but as a broader capability encompassing critical thinking, ethical awareness, digital agility, and reflective practice. Developing these capabilities will be increasingly important as graduates enter workplaces in which AI technologies are becoming commonplace.

Limitations and future research

Several limitations should be acknowledged. First, the study was conducted within a single institution and focused on business-related modules, which may limit the transferability of the findings to other disciplinary contexts. Future studies should explore the implementation of curriculum-embedded AI literacy across a wider range of disciplines and institutional settings.

Second, the study adopted a cross-sectional rather than longitudinal design. Data were collected from different student groups at each level of study rather than tracking the same cohort over time. Consequently, the findings provide indicative evidence of progression rather than direct evidence of individual AI-literacy development. Longitudinal research following students throughout their degree programmes would provide deeper insight into how AI literacy develops through sustained curriculum integration.

Third, as the study relied on self-reported perceptions and did not include objective measures of AI-literacy competence, the findings should not be interpreted as evidence of actual gains in AI literacy. While such data provide valuable insights into students' experiences, they do not offer objective measures of competence. Future research could strengthen understanding of



AI-literacy development through the inclusion of performance-based assessments, learning analytics, educator perspectives, and analysis of student work.

Future research should also investigate how specific pedagogical approaches, such as AI co-creation, peer review of AI-generated outputs, prompt engineering instruction, and discipline-specific ethical case studies, influence the development of advanced AI-literacy capabilities.

Conclusion

This study examined the impact of curriculum-embedded AI activities on students' AI-literacy development across three undergraduate business modules. The findings suggest that students perceive strategically designed AI learning activities as supporting their AI-literacy development. The study further highlights the importance of aligning AI-related activities with students' developmental stages and intended learning outcomes. While students reported positive learning experiences and the development of transferable skills, they also identified a need for greater support in areas such as prompt engineering, critical evaluation of AI outputs, and responsible AI use. In particular, the findings suggest that ethical dimensions of AI literacy require more explicit attention within curriculum design.

As AI continues to reshape HE and professional practice, institutions face increasing responsibility for preparing students to engage with AI critically, ethically, and effectively. The findings suggest that AI literacy is most effectively developed through a structured, curriculum-wide approach that combines technical competence with critical reflection, ethical awareness, and informed decision-making. Such an approach will be essential in ensuring that graduates are equipped not only to use AI technologies, but also to evaluate, challenge, and apply them responsibly in academic, professional, and societal contexts.

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Author details

Lilian Ngozi Schofield is Reader in Management Education and Deputy Director of Education (Student Experience) at the School of Business and Management, Queen Mary University of London, where she is also Co-Director of the Centre for Education and Scholarship Research in Economics, Finance and Business Management. A HEA Senior Fellow, Lilian's scholarship and publications focus on management education, curriculum innovation, student employability, and AI-enhanced teaching and learning. She has led institutional initiatives and funded projects in these areas and has published extensively on the subject.

Xue Zhou is Professor in AI in Business Education and Dean of AI in the College of Business at the University of Leicester. Her research focuses on artificial intelligence in education, AI literacy, digital literacy, technology-enhanced learning, and the adoption of emerging technologies in higher education. She has led several externally funded projects exploring the integration of AI into teaching, learning, and assessment, and has published extensively in these areas. Professor Zhou serves as associate editor for *Intelligent Technologies in Education*.

Georgy Petrov is Reader in Management Education and Practice and Director of Skills and Employability at the School of Business and Management, Queen Mary University of London. He is a Senior Fellow of the Higher Education Academy and holds a PhD in Higher Education



and Organisation Studies from University College London. His scholarship interests include employability, experiential learning, project- and problem-based learning, and curriculum innovation. Georgy has published and presented widely on these topics and is the author of the book *Project-Based and Problem-Based Learning*. He has also led several institutional initiatives focused on enhancing student learning and graduate outcomes.

Andrew Woon is a Senior Lecturer at Monash University Malaysia. His research explores compassion and wellbeing in higher education, with particular attention to the experiences of faculty and students, and the growing role of artificial intelligence in shaping learning and wellbeing. His doctoral work examined compassion fatigue among academics in private higher education institutions. He continues to develop this area of inquiry through collaborative research and writing, contributing to wider conversations on how universities can better support the people within them. His work has been shared through academic publications, sector blogs, and international conferences.

ORCID

Lilian N. Schofield  <https://orcid.org/0000-0002-2318-7862>

Xue Zhou  <https://orcid.org/0000-0002-7242-0958>

Georgy Petrov  <https://orcid.org/0000-0002-6312-6255>

Andrew Woon  <https://orcid.org/0009-0007-4376-6099>