AI Literacy in the Classroom: Transforming Education through Educational Technologies

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Abstract. The integration of Artificial Intelligence (AI) literacy into college curricula is a pressing but complex challenge, particularly in non-technical fields like business. This paper presents a case study of a pedagogical intervention designed to embed AI literacy within a required college mathematics course. The intervention employed a Problem-Based Learning (PBL) framework where 120 business students used tools like ChatGPT and matrix calculators to solve an authentic data-driven business problem. We analyzed data from the final assessment artifact – a digital magazine – to evaluate the development of specific AI literacy competencies. Initial findings from this pilot implementation indicate that the PBL approach was effective in developing students' skills in data-driven argumentation, critical evaluation of AI-generated outputs, and the ability to connect abstract mathematical models to practical AI applications. The study demonstrates a promising replicable model for integrating AI literacy into foundational courses, but also highlights key challenges, including the need for explicit scaffolding in critical AI evaluation. This paper contributes empirical insights from an initial implementation, offering a practical framework and actionable lessons for educators designing AI literacy curricula.

Keywords: IA literacy, curriculum design, PBL (problem based learning), educational technology.

1. Introduction

The rapid integration of Artificial Intelligence (AI) into professional industries has created a pressing need for higher education to develop robust AI literacy curricula (Zafari *et al*., 2022). For students in applied fields like business, proficiency is no longer limited to disciplinary knowledge but must include the ability to utilize, interpret, and critically evaluate AI-driven systems for decision-making (Dosdoğru, İpek and Göçken, 2020). While the importance of AI literacy is clear, a significant pedagogical gap remains there is a lack of empirically documented models demonstrating *how* to effectively integrate these competencies into foundational non-technical courses like college mathematics. We argue that foundational mathematics courses, while frequently dismissed by students as abstract, are in fact the ideal context to cultivate AI literacy.

Their perceived weakness is their strength: they teach formal models (e.g., product matrix, eigenvalues and eigenvectors) that underpin powerful AI applications in fields like marketing and logistics (Talaat *et al.*, 2023). The problem is one of perception and access. By strategically integrating AI tools, we create a pedagogical bridge. Students, who might otherwise be intimidated by the complexity of applying these models, are now empowered by technology to tackle authentic real-world business problems. This intervention is therefore designed to directly confront student disengagement by transforming a course they perceive as a disconnected hurdle into a practical training ground for data-driven decision-making with AI (Dosdoğru, İpek and Göçken, 2020; Khattak *et al.*, 2023).

This study addresses this implementation gap by presenting a case study of a pedagogical intervention designed to embed AI literacy within a required linear algebra course for business students. Conducted in a Latin American university context where traditional teaching methods persist, our work provides a stark illustration of the potential of such an approach. Our core argument is that AI literacy cannot be taught in a vacuum; it must be situated within authentic domain-specific problems. To this end, we employed a Problem-Based Learning (PBL) framework where students were required to use AI tools (ChatGPT) and computational software (matrix calculators, such as MatrixCalc) as instruments to solve a complex business problem. Our model was deliberately sequenced to augment, not replace, traditional instruction: students first learned the foundational mathematical logic before using AI tools to apply that understanding, generate data-driven arguments, and critically assess the AI's outputs.

This paper addresses this gap by documenting a case study of pilot implementation. Our primary contribution is a detailed and replicable pedagogical model for embedding AI literacy within a quantitative course. This model, grounded in a Problem-Based Learning (PBL) framework, is specifically designed to develop students' core competencies in data-driven argumentation and the critical evaluation of AI-generated insights. By presenting initial empirical evidence from student work and feedback, we offer practical lessons for refinement and implementation. Ultimately, this study seeks to answer a central research question:

How can a PBL framework, enhanced with AI tools, be structured to effectively develop tangible AI literacy competencies in a traditional college classroom?

2. Foundational Frameworks for an AI Literacy Curriculum

The design of our pedagogical model for integrating AI literacy is grounded in three foundational frameworks that collectively address the problem, define the pedagogical approach, and guide the integration of technology. First, we outline the problem framework by examining the persistent challenges of student disengagement in applied mathematics and the corresponding need for AI literacy. Second, we establish our pedagogical framework, arguing Problem-Based Learning (PBL) as the core instructional strategy. Finally, we detail the technological framework, explaining the principles behind the integration of AI tools as cognitive scaffolds.

2.1. *The Problem Framework: Disengagement and the Need for AI Literacy*

A significant challenge in higher education, particularly in service courses for non-STEM majors, is the profound disconnect students often feel with quantitative subjects. Decades of research have documented high levels of math anxiety and a perception of mathematics as an irrelevant abstract hurdle (Richardson and Suinn, 1972). More recent studies confirm this is not merely a matter of anxiety, but of fundamental disengagement driven by a perceived lack of connection to professional aspirations (Merchant, 1980). This manifests in superficial learning strategies, where students focus on passing exams rather than achieving genuine understanding.

This academic disengagement does not happen in a vacuum. It is often exacerbated by the traditional learning environment itself. Students' perceptions of the instructional format can be a significant barrier to deep learning, particularly in technology-mediated contexts where the pedagogy does not align with their needs or expectations (Schmidt and Köhler, 2013). This presents a challenge for instructors: while we are primarily content experts, we are increasingly expected to create classroom environments that not only deliver information but also foster the focus and resilience students need to learn effectively.

Simultaneously, the professional world for which these students are preparing is undergoing a rapid transformation driven by Artificial Intelligence. The ability to understand, apply, and critically evaluate AI systems – core tenets of AI literacy – is becoming a foundational competency for decision-making in fields like business and finance (Dosdoğru, İpek and Göçken, 2020). This creates a dual imperative. Therefore, a pedagogical model is needed that can address both challenges simultaneously, leveraging AI literacy as a bridge to make abstract mathematics relevant and engaging for today's students.

2.2. *A Pedagogical Response: The Rationale for Problem-Based Learning (PBL)*

Addressing this dual challenge requires more than just adding technology to a traditional lecture format; it demands a fundamental shift in pedagogical strategy. While various active learning methodologies offer potential solutions, Problem-Based Learning (PBL) is arguably uniquely suited to this task. Its inherent focus on authentic complex problems provides the ideal framework not only to motivate students but also to situate the use of AI tools in a meaningful professional context.

To address the problem of perceived irrelevance, a curriculum can be built upon a PBL framework. Unlike traditional lecture-based models that often fail non-specialist students by presenting abstract theories first, PBL fundamentally inverts this structure (Savery, 2015). Such an approach begins with a complex authentic problem that mirrors a professional scenario. For instance, in a business context, this could be a problem requiring predictive modelling. This design provides students with a compelling immediate reason to learn abstract concepts, as these concepts transform from decontextualized rules into necessary instruments for solving the problem at hand. The power of PBL, therefore, lies in its ability to reframe the entire learning enterprise by making the utility of knowledge immediately apparent (Salam 2022).

Moreover, PBL shifts the classroom dynamic. It fosters skills that are crucial for the modern workplace but often neglected in traditional math courses, most notably collaboration. In professional settings, problem-solving is rarely a solitary act; it is a social process of dialogue and co-construction. By structuring learning around teamwork, PBL mirrors this authentic professional practice. Furthermore, peer collaboration provides a critical support system, helping to mitigate the stress and anxiety that individual students might feel when facing a complex open-ended problem. This prepares them not only cognitively but also effectively for the collaborative demands of their future careers.

2.3. *The Technological Framework: AI as a Cognitive and Assessment Scaffold*

The traditional PBL model can be powerfully enhanced by the strategic integration of technological tools, which function as cognitive mediators that reshape the learning process (Wertsch, 1991). This integration is not merely an option, but a necessity when dealing with truly authentic real-world problems. While foundational mathematical logic can be taught with simplified small-scale examples, the complex and computationally intensive nature of authentic business problems often require the use of computational tools. Therefore, a well-designed curriculum must reflect this professional reality: it should first establish foundational understanding through direct instruction and then introduce technology in a controlled manner to allow students to tackle problems at a scale and complexity they would encounter in their careers. This approach ensures that technology serves to augment, not replace, conceptual understanding.

On one hand, computational tools can serve to reduce extraneous cognitive load (Sweller, 1988). By automating tedious procedural calculations, a known source of math anxiety (Goetz *et al*., 2013), students can allocate their finite cognitive resources toward higher-order tasks like conceptual modeling and interpretation. This aligns with principles of Universal Design for Learning (UDL) by providing support that accommodates diverse levels of mathematical preparedness (Tarconish *et al*., 2023). On the other hand, generative AI tools like Large Language Models (LLMs) can function as dialogic scaffolds to support the complex skill of mathematical argumentation (Zhou *et al*., 2022). These tools can prompt students to translate quantitative results into coherent data-driven narratives, fostering a critical aspect of AI literacy: the ability to evaluate and refine AI-generated outputs. This positions the AI as a partner in a human-AI collaboration model, where technology augments human cognition (Lund and Wang, 2023).

Finally, to synthesize these pedagogical and technological elements, an assessment artifact as authentic as the problem itself is required. A traditional exam would undermine the entire approach by forcing a return to rote memorization. Therefore, a performance-based digital project becomes a necessary alternative. Such a project serves a dual purpose. First, it provides a platform for assessment as learning, where the act

of creation is a significant learning experience in itself. Second, it allows for a holistic evaluation of the skills central to AI literacy: constructing coherent arguments and communicating complex quantitative ideas in a professional manner.

3. Methodology

This study employed a case study methodology to document and evaluate the initial implementation of a pedagogical model for AI literacy within a college mathematics course. Our approach was primarily qualitative and descriptive, centered on analyzing student processes and artifacts to assess the development of specific AI literacy competencies as outlined in our objectives.

3.1. *Research Context and Participants*

The pilot implementation was conducted in a required gateway linear algebra course for undergraduate business students at a large private university in Latin America. The study cohort consisted of 120 students. This context was deliberately chosen for two reasons: (1) the persistence of traditional lecture-based teaching methods provided a stark contrast against which to evaluate an innovative pedagogy, and (2) the students, as future business professionals, represent a key demographic for whom AI literacy is a critical emerging competency. All participation was a required part of the course activities.

3.2. *The AI Literacy Pedagogical Model: Design and Implementation*

Our pedagogical model was designed to address curricular integration by embedding AI literacy within the existing course topic of product matrix and eigenvalues/eigenvectors. This PBL project built upon foundational skills developed earlier in the course. Prior to the intervention, students had already been taught to model simple two-state Markov chains by hand, ensuring they understood the underlying logic before engaging with computational tools. The model consisted of a three-week Problem-Based Learning (PBL) project with three core components:

1. The Authentic Problem: Students, working in pairs, were tasked with solving a given business problem that required predictive modeling using a five-state Markov chain. The problem was designed to be complex enough to necessitate the use of technology but grounded enough to feel relevant to their field. The decision to mandate paired work was a central pedagogical choice. While we introduced AI as a sparring partner, we argue that it cannot and should not replace human-to-human dialogue. The paired structure was designed to ensure that students engaged in crucial social and cognitive processes: they had to negotiate meaning,

co-construct their arguments, and mutually verify the outputs of the AI tools. This peer interaction serves as a vital safeguard against the uncritical acceptance of AI-generated content and provides the immediate, supportive dialogue necessary to navigate the complexities of the task.

2. The AI-Enhanced Toolkit: We required students to use two types of technology as integral instruments for the task: MatrixCalc, an online computational tool, to handle complex calculations; and ChatGPT, a generative AI, to assist in structuring data-driven arguments.

3. The Performance-Based Assessment: The final product was a digital magazine where students synthesized their findings, presented their predictions, and justified their recommendations.

The implementation followed a fundamentals-first sequence. In the weeks prior to the intervention, students learned the underlying mathematical logic of matrix operations and Markov chains through direct instruction and non-AI-based exercises. Only after this foundation was established did we launch the PBL project, which began with a dedicated workshop on the ethical and effective use of the AI toolkit.

3.3. *Data Collection and Analysis: Mapping Evidence to Objectives*

To evaluate our model, we collected and analyzed multiple sources of evidence. The analysis was primarily qualitative, focused on student-generated artifacts and self-reported feedback. We conducted a qualitative content analysis of these submissions, assessing them with a detailed rubric. The rubric criteria were designed to measure: (a) the accuracy of the mathematical application of Markov chains, (b) the coherence and logical strength of the data-driven arguments, and (c) the clarity and professionalism of communication. This provided direct evidence of students' ability to solve complex problems and synthesize their learning.

To investigate the use of AI for argumentation and critical evaluation, we used two data sources. First, digital magazines were specifically examined for evidence of critical engagement with AI. The rubric included a criterion that assessed students' ability to not just use, but also to verify, question, or contextualize AI-generated outputs. Second, we conducted informal group interviews with a subset of students. These qualitative instruments gathered self-reported data on *how* students used ChatGPT as a sparring partner and the processes they employed to critically evaluate its suggestions.

4. Results of the Pilot Implementation

This section presents the initial empirical findings from our pilot implementation. The results are organized around the key AI literacy competencies the intervention was designed to foster, drawing evidence from the qualitative analysis of the final digital magazine artifacts and student self-reported feedback from surveys and interviews.

4.1. *Overall Performance in the Authentic Task*

The primary measure of the model's success was students' performance on the final digital magazine project. The results indicate a generally positive outcome, but also reveal significant variability across the student cohort, as illustrated in the frequency distribution in Fig. 1.

The mean score for the 60 collaborative projects was 4.2 (SD = 1.06) on a 5-point scale. However, as Figure 1 shows, this average masks a strongly right-skewed distribution. A substantial majority of students (62.5%) achieved excellent scores in the 4.1–5.0 range, indicating a high level of success in meeting the project's learning objectives. At the same time, the histogram also reveals a small but important tail of students who struggled, with 11.7% scoring 3.0 or below.

This variability in outcomes underscores that while the pedagogical model was highly effective for most, it was not universally so. To understand the sources of this variability, we broke down the project scores according to the four main criteria of our assessment rubric. The results of this breakdown are summarized in Table 1.
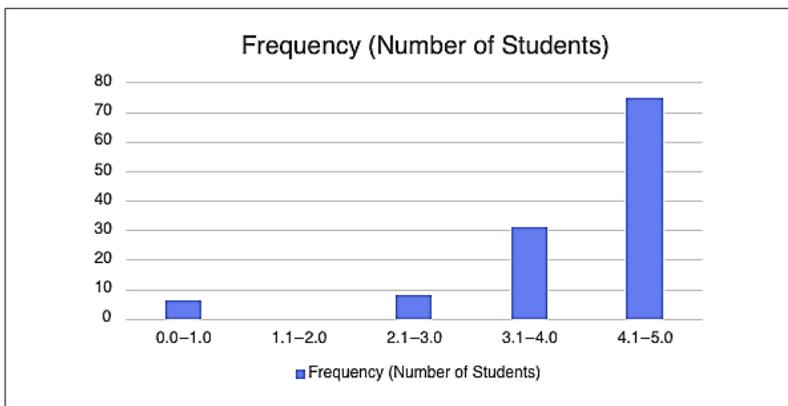

Fig. 1. Frequency Distribution of Final Grades on the Digital Magazine Project (N = 120).

Table 1

Descriptive Statistics for Rubric Criteria on the Digital Magazine Project (N=60 Projects)

Rubric Criterion	Max Score	Mean (out of Max)	Mean (5-point scale)	Std. Dev. (5-point scale)
Professional Design	20	18.7	4.68	0.70
Argumentation & Coherence	40	34.1	4.26	1.18
Critical Engagement with AI	20	16.3	4.08	1.13
Mathematical Accuracy	20	14.8	3.70	1.45
Overall Score	100	83.9	4.20	1.06

The following sections will now delve into a qualitative analysis of the two central AI literacy competencies: data-driven argumentation and critical engagement with AI.

4.2. *Development of Data-Driven Argumentation Skills*

A key objective of the model was to develop students' ability to construct data-driven arguments using AI as a support tool. The analysis of digital magazine artifacts indicates considerable success in this area. The average score on the rubric criterion for argumentation and coherence was 4.26 (SD = 1.18) on a 5-point scale. This high score suggests that most student groups were able to effectively translate the quantitative outputs from their models into a clear, persuasive narrative to justify their business recommendations.

Qualitative feedback from student interviews provides context for this success. They reported that using ChatGPT as a sparring partner was instrumental. As one student noted, *"I had all the numbers, but I didn't know how to start. ChatGPT helped me create an outline and then I could fill in my own analysis."* This suggests that the AI tool was an effective scaffold for structuring complex arguments.

4.3. *Critical Engagement with AI: Successes and Persistent Challenges*

A central goal of the AI literacy curriculum was to foster not just the *use* of AI, but its *critical evaluation*. The results on this front were promising but also highlighted a critical area for development. The average score on the rubric criterion for critical engagement with AI was 4.08 (SD = 1.13), indicating that most students demonstrated a basic level of critical use.

However, a deeper look reveals a more complex picture. While students were proficient at using AI to structure their arguments, their ability to critically evaluate the AI's underlying mathematical assumptions was less developed. This is starkly supported by the finding that the lowest average score across all rubric criteria was in mathematical accuracy (M = 3.70, SD = 1.45).

A specific, recurring error in the student submissions explains this discrepancy. In our instruction, we taught the Markov chain model where transition matrix columns sum to 1. In contrast, ChatGPT often generates matrices where the *rows* sum to 1. Despite warnings, many students failed to identify this fundamental error. Furthermore, we observed concrete evidence of uncritical copy-pasting in several submissions. A tell-tale sign was the duplication of formatted equations, an artifact that occurs when transferring content directly from the AI without careful review. This suggests that for a subset of students, the AI functioned as a source of answers to be copied, rather than as a sparring partner for cognitive engagement.

This finding points to a crucial lesson for AI literacy curricula: instruction must go beyond demonstrating *how to use* AI and explicitly scaffold the skills of verification, critical scrutiny, and the evaluation of the AI's underlying assumptions.

4.4. *Fostering Creativity and Professional Communication through an Authentic Artifact*

Beyond the core competencies of argumentation and critical thinking, the digital magazine artifact was designed to foster creativity and professional communication. The results indicate that this was arguably the most successful aspect of the intervention. The average score on the rubric criterion for professional design and presentation was the highest of all categories, at 4.68 (SD = 0.70) on a 5-point scale.

This high score reflects more than just technical proficiency; it points to a remarkable level of creative investment, far exceeding what is typically seen in a traditional mathematics course. Our qualitative analysis of the submitted magazines revealed a surprising diversity of creative approaches, with students reframing the mathematical problem through compelling narrative genres:

- One pair transformed their Markov chain analysis of climate change into a comic book, where four of the five states were depicted as villains, and the desired steady state was the hero.
- Another group wrote their entire analysis as a well-articulated short story, skilfully weaving the mathematical reasoning into the narrative while minimizing the use of formal equations to maintain the literary style.
- A third pair contextualized their entire project within the world of a popular Latin American telenovela, "Yo soy Betty, la fea," using the fictional company "Ecomoda" as the basis for their business problem.

These examples demonstrate a level of ownership and creative engagement that suggests the performance-based, authentic nature of the task was a powerful motivator. As one student commented, *"It was the first time a math project didn't feel like a math project. It felt like we were creating something real."* This shift in perception – from a technical exercise to a creative product – appears to be a crucial component in the model's success at fostering a deeper and more personal connection to the material.

5. Discussion and Implications

This case study documented the pilot implementation of a pedagogical model designed to embed AI literacy in a gateway mathematics course. The results indicate that the AI-enhanced PBL intervention was largely successful in fostering key competencies, but also revealed significant challenges, particularly in the development of critical AI evaluation skills. This section interprets these findings, outlines actionable lessons for curriculum designers, acknowledges the study's limitations, and suggests directions for future research.

5.1. *Interpretation of Key Findings: The Double-Edged Sword of AI Scaffolding*

Our findings present a nuanced picture of integrating AI in the classroom. On one hand, the high performance in data-driven argumentation (M=4.26) and professional design (M=4.68), supported by positive student feedback, suggests that AI tools like ChatGPT are exceptionally effective as scaffolds for structure and communication. They appear to lower the barrier to entry for complex tasks, helping students organize their thoughts and present their work professionally. The creative outputs, from comic books to short stories, further suggest that this approach can foster a deep sense of ownership and engagement.

On the other hand, the lower scores in mathematical accuracy (M=3.70) and the specific errors observed (e.g., the row-sum vs. column-sum matrix confusion, uncritical copy-pasting) act as a crucial cautionary tale. They reveal the double-edged sword of AI: the same tools that scaffold argumentation can also enable superficial engagement *if not used critically*. The AI's confident, fluent outputs can mask underlying mathematical errors, and students, particularly novices, may lack the skills or inclination to question them. This suggests that the central challenge of AI literacy is not teaching students to *use* the tools, but to *distrust* them productively.

5.2. *Actionable Lessons for AI Literacy Curriculum Design*

Based on these findings, we propose three critical lessons for educators and curriculum designers implementing similar initiatives:

1. A Fundamentals-First Sequence is Non-Negotiable. Our findings underscore that AI tools are most effective when they augment, not replace, foundational knowledge. The students' ability to even begin to question the AI's output (like the matrix error) was entirely dependent on their prior, non-AI-based instruction. Any AI literacy curriculum must begin by establishing this conceptual foundation, ensuring students have a mental model against which they can judge the technology's results.
2. Critical Evaluation Must Be Explicitly Scaffolded and Assessed. Our study clearly showed that critical AI evaluation skills do not emerge passively. Instruction must move beyond simply demonstrating *how to use* AI and explicitly teach students *how to question* it. This involves scaffolding the skills of verification and scrutiny. Based on our findings, we propose a key refinement for future implementations: adding an intermediate behind-the-scenes checkpoint. Before students finalize their projects, they would participate in a brief interview-style session with the instructor. In this session, they would be required to manually walk through a small part of their model's calculation and explain the mathematical logic behind a key AI-generated argument. This behind-the-scenes check would serve two purposes: it would make their cognitive processes visible, allowing for targeted feedback on their deepest understanding, and it would explicitly signal that the *process* of reasoning, not just the final product, is what is being valued and assessed.

3. Authentic, Performance-Based Assessment Drives Meaningful Engagement. The digital magazine artifact was arguably the most successful component. It shifted the learning objective from finding a single correct answer to constructing a persuasive, professional argument. This holistic, creative task provides a natural and motivating context for using AI tools for communication and design. Our findings strongly suggest that the more authentic and professionally relevant to the assessment, the more likely students are to engage with it in a deep and meaningful way.

5.3. *Limitations and Future Research*

This study has several limitations inherent to its nature as an initial pilot implementation. First, as a single case study with 120 students in one course, the findings are not generalizable but are intended to offer transferable insights. Future work should replicate this model in different institutional and disciplinary contexts. Second, our analysis was primarily qualitative and descriptive. Future iterations should incorporate more robust quantitative measures of critical thinking to track skill development over time. Finally, this study did not compare the intervention against a control group. A quasi-experimental design would be needed to isolate the specific effects of the AI-enhanced model from other confounding factors. Future research should also explore the long-term impact of such interventions on students' academic and professional trajectories.

5.4. *Conclusion*

The integration of AI literacy into higher education is not a technological challenge, but a pedagogical one. This case study demonstrates that a thoughtfully designed PBL-based model can effectively leverage AI tools to make abstract subjects like mathematics more relevant and engaging. However, it also serves as a critical reminder that the goal of AI literacy is not to create proficient users of AI, but to cultivate critical, discerning thinkers. The practical lessons learned from this implementation offer a replicable framework for other educators, moving the conversation from *why* AI literacy is important to *how* it can be implemented responsibly and effectively in the classroom.

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