Journal Club Insights: Case Studies on Generative AI in Biomedical Laboratory Science Education

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Abstract

This study explores the utilization of Generative Artificial Intelligence (GenAI) in Journal Club (JC) sessions within Biomedical Laboratory Science (BLS) education, using ChatPDF. Focusing on case studies of 6th semester students, our research combines observational and tracking methodologies to assess student engagement with ChatPDF. Guided by a conceptual framework comprising self-efficacy with agency, digital literacy, data use, and critical analysis, the study examines students' interactions with ChatPDF across three JCs. This research utilizes sequential mixed methods design, incorporating data from surveys and interviews, gaining deeper insights into students' experiences and perceptions regarding GenAI. Findings show that while some students strategically used ChatPDF to support comprehension, preparation, and discussion, others relied on it primarily for translation or surface-level understanding. High self-efficacy was associated with deeper engagement and autonomous use of the tool, whereas lower self-efficacy often led to limited or passive interaction. While this study shows that GenAI has the potential to assist students in overcoming educational challenges, it also sheds light on the pitfalls associated with over-reliance on GenAI, the need for preserving student agency, and the importance of ensuring ethical and meaningful learning experiences.

Introduction

In recent years, Generative Artificial Intelligence (GenAI) has made significant advancements and has become increasingly integrated into various aspects of daily life, including education (Michel-Villareal et al., 2023; Robertson et al., 2024). The release of OpenAI's generative AI application, ChatGPT-3.5, in November 2022 has significantly transformed teaching and learning in higher education (Christ-Brendemühl, 2025). The European Commission's Digital Education Action Plan (2021–2027) outlines two strategic priorities (European Commission, 2020). One priority is to develop a high-performing digital education ecosystem, supported by strong organizational capabilities and educators who are both digitally competent and confident. The second priority focuses on enhancing digital skills and competencies, emphasizing the need for a deep understanding of data-intensive technologies, such as AI. As educational research intensifies, the focus is increasingly on how educators and students can effectively harness this technology to maximize the benefits of digital education. Digital education is continually evolving, driven by the advent of new technologies that promise to enhance learning experiences and outcomes (Selwyn, 2022). It may take a decade for academia to fully adjust to the emergence of GenA (Christ-Brendemühl, 2025; Zawacki-Richter et al., 2019) I.

Recent findings indicate that most university guidelines explicitly allow both lecturers and students to engage with GenAI, highlighting the growing emphasis on AI literacy as a fundamental skill in higher education (Christ-Brendemühl, 2025). Institutions increasingly recognize the need to prepare students for the evolving demands of the workforce, where AI-driven technologies play an integral role (Maeda & Socha-Dietrich, 2021; Maekawa et al., 2022; Vuorikari et al., 2022). However, alongside these opportunities come pressing concerns about the potential over-reliance on AI, the impact on students' critical thinking skills, and the degree to which AI use supports or undermines academic (Michel-Villarreal et al., 2023). These concerns are particularly relevant in professional education programs, such as Biomedical Laboratory Science (BLS), where students are required to develop a solid foundation in evidence-based practice, scientific literacy, and analytical reasoning (Ilic et al., 2020; Johnson et al., 2023).

GenAI applications such as ChatPDF have gained attention for their ability to facilitate student learning through personalized interactions and advanced data processing capabilities. These tools hold significant promise for higher education (Xia et al., 2024. Unlike other GenAI tools that often emphasize general conversational abilities or creative generation, ChatPDF is specifically designed for analyzing complex documents such as research papers (OTIO.AI, 2024.). In structured academic settings such as Journal Clubs (JCs), where students engage

deeply with scientific literature, tools like ChatPDF may offer new ways to enhance engagement and comprehension.

JCs have a rich history as a widely used educational method in educational settings, with origins tracing back nearly two centuries (Cole et al., 2020; Ilic et al., 2020; Turner et al., 2020). Initially designed to help physicians stay updated on emerging research and integrate findings into clinical practice, JCs have evolved into a versatile pedagogical framework in professional educations (Häggman-Laitila et al., 2016; Johnson et al., 2023; Turner et al., 2020; Purnell et al., 2017). They promote collaborative learning, encourage continuous study, and serve as a platform for disseminating scientific knowledge (Cole et al., 2020; Häggman-Laitila et al., 2016). Furthermore, JCs facilitate the development of critical thinking and analytical skills while motivating participants to engage deeply with academic content (Purnell et al., 2017). These sessions are particularly effective for fostering knowledge transfer, staying current with the literature, and enhancing participants' ability to critically evaluate research (Häggman-Laitila et al., 2016). Despite their ongoing importance, there is a significant gap in the literature regarding how GenAI tools, like ChatPDF, influence student engagement and learning outcomes in JC settings. As AI integration into education increases, understanding how these tools affect learning becomes increasingly crucial.

This study aims to fill this gab by investigating the effectiveness of ChatPDF in facilitating learning experiences among 6th semester students in the BLS program. This study is situated in JC sessions, where students engage collaboratively to discuss and analyze scientific literature. These sessions provide a structured framework for exploring how ChatPDF can support critical thinking, collaborative learning, and individual preparation.

Building on this context, this study adopts a two-step approach to explore the following research questions:

- How do students with different academic proficiency levels use GenAI (ChatPDF) to engage with scientific literature in preparation for JC sessions?
- How does students' use of ChatPDF affect their self-efficacy, agency, digital literacy, data use, and critical analysis in the context of JCs?

GenAI's impact on education and academic integrity

Between 2022 and 2024, the rapid advancement of AI raised educators' concerns about plagiarism, cheating, and the decreasing relevance of traditional assignments (Cotton et al., 2024). Prior research has raised concerns that tools like ChatGPT and ChatPDF might lead students to bypass critical thinking and creativity, potentially undermining academic integrity, and traditional forms of assessment (Cotton et al., 2024; Zawacki-Richter et al., 2019). There were also worries that AI could make some assignments obsolete, challenging core principles of learning and assessment in higher education (Zawacki-Richter et al., 2019).

However, these challenges also triggered a proactive exploration of how GenAI could be used to enhance educational practices rather than undermine them. Educators and institutions began to recognize that, when strategically integrated, AI could serve as a powerful ally in improving student engagement, personalizing learning experiences, and expanding access to educational resources (Christ-Brendemühl, 2025). In this context, ChatPDF has emerged as a tool that specifically supports the analysis and understanding of complex scientific literature, potentially enhancing students' engagement with academic texts in a more focused way than other general-purpose AI tools.

The use of AI tools can assist institutions in achieving these goals by automating administrative tasks, enhancing efficiency, and providing scalable solutions for personalized learning and education (Luckin & Holmes, 2016).

From a technological standpoint, the evolution of AI tools, especially in natural language processing and adaptive learning systems, has opened new possibilities for creating dynamic and interactive learning environments. AI-tools driven platforms, like ChatPDF, can now analyze individual learning patterns and tailor educational content to meet the specific needs of each student, thus fostering a more inclusive and effective learning experience. Moreover, these tools can support continuous assessment and feedback loops, helping students to identify and address their weaknesses in real time, thereby enhancing their learning outcomes. (Holmes et al., 2019)

The recent recommendations from the OECD also emphasize the need to reimagine education to better meet the demands of a rapidly changing world (OECD, 2024). By advocating for the integration of digital tools like ChatPDF and promoting equity and inclusion, the OECD highlights the importance of using technologies like AI to create more personalized and effective educational experiences. These recommendations align with the ongoing shift towards AI-enhanced education, underscoring the necessity for educators to innovate and adapt traditional methods to remain relevant in an increasingly digital world. The Danish Ministry of Education and Research (UVM) echoes these sentiments, advocating for the responsible integration of AI tools like ChatGPT and ChatPDF in educational settings (Børne- og Undervisningsministeriet, 2024). UVM's recommendations emphasize the importance of equipping educators with the necessary skills and training to use AI effectively, developing ethical guidelines for AI use, and rethinking assessment methods to ensure that AI supports rather than undermines academic integrity and learning outcomes. These guidelines align with broader global efforts to ensure that AI contributes positively to the evolution of education.

The use of GenAI offers opportunities to rethink and redesign the curriculum to better prepare students for a future where AI will be a ubiquitous part of their professional and personal lives. By integrating AI into the learning process, educators can encourage students to develop critical AI literacy, understand the ethical implications of AI, and engage in more sophisticated forms of problem-solving and creative expression (Nye, 2015).

Analytical conceptualization

Technology research has shifted from optimism to realism (Castañeda & Selwyn, 2018; Henderson et al., 2017; Selwyn, 2022; Stenalt, 2022; Stenalt & Hachmann, 2024), which has led to critical studies on the production and objectives of digital technologies (Stenalt, 2022; Stenalt & Lassesen, 2022; Williamson, 2019). As technology research shifts from optimism to realism, AI in education has followed suit. Initially, much of the conversation around AI in education was characterized by high expectations and a belief in the transformative potential of AI to revolutionize teaching and learning (Stenalt & Hachmann, 2024). Proponents envisioned AI-driven tools as solutions to a wide range of educational challenges, from personalized learning and automated assessment to addressing achievement gaps (Michel-Villarreal et al., 2023). However, as the implementation of AI in educational contexts has progressed, scholars have increasingly called for a more critical and nuanced examination of these tools. This emerging discourse emphasizes the need to critically assess the implications of AI on pedagogy, ethics, and equity in education. Researchers are now exploring not just how AI can enhance educational processes, but also how it might reinforce existing inequalities,

shape pedagogical practices in unintended ways, and introduce new ethical dilemmas related to data privacy and algorithmic bias (Selwyn, 2022).

This section will closely examine some central analytical concepts used in research on GenAI. Shifting the focus from the socio-economical forces driving the adoption of GenAI in education, this study aims to explore the space where students interact with and use GenAI in education. It seeks to understand how these tools influence the educational experiences and practices of students.

We deliberately downplay the numerous approaches to GenAI that exist. Instead, we choose to focus on the analytical concepts that are prominent within cognitive and educational theories. In the context of research on GenAI in education, several central analytical concepts guide our understanding of how these tools are integrated into and impact the learning process. By employing a case study approach, our methodology aligns with the need to deeply explore these concepts — such as self-efficacy, agency, digital literacy, data uses, and critical analysis — within a real-world educational setting.

A central concept within cognitive and educational research is 'self-efficacy'. Self-efficacy describes students' beliefs and confidence in their own resources and abilities to achieve set goals or to overcome challenges (Bandura, 2006). The higher the self-efficacy, the more likely individuals are to succeed in the actions and changes required by a goal (van Dinther et al., 2011). Self-efficacy is critical for understanding how the use of GenAI tools influences students' beliefs in their ability to successfully engage with and master learning tasks. This concept helps to highlight the psychological impact of GenAI tools, as they can either bolster or undermine students' confidence in their academic skills and their capacity to achieve learning outcomes.

Self-efficacy and agency are closely related concepts that are central to understanding how individuals engage in actions and make decisions (Klemencic, 2017; Stenalt, 2022; Stenalt & Lassesen, 2022). Self-efficacy refers to an individual's belief in their ability to successfully execute tasks and achieve specific goals. It is about one's confidence in their own capabilities. Agency involves the capacity of individuals to act independently and make choices that influence their environment and their own lives. It reflects an individual's ability to initiate actions based on their intentions and desires. In essence, self-efficacy is about believing in one's capabilities, while agency is about acting on those beliefs (Henderson et al., 2017; Hodgson & McConnell, 2019; Jääskelä et al., 2017; Klemencic, 2017; Stenalt & Lassesen, 2022). High self-efficacy empowers individuals to exercise their agency, and successful agency further reinforces self-efficacy.

One of the criticisms of the optimistic discourse about technologies in educational research and the associated studies is the oversimplified nature of learning and the interactions between humans and technology (Stenalt, 2022). It is crucial to consider the interaction between AI and learning through the lens of student agency to guarantee that learning experiences remain both meaningful and ethical (Stenalt & Hachmann, 2024). Evaluations that capture how students experience their learning and the factors influencing these experiences, rather than assessments that merely determine whether digital interactions were effective are much needed in this research area (Bond et al., 2020). The domain of digital literacy and data uses reflects the role of GenAI in fostering students' digital literacy and their ability to navigate complex digital environments (Biggins et al., 2017; Demirok et al., 2023). It raises important ethical considerations regarding data privacy, the ownership of educational data, and the potential for bias in algorithmic decision-making.

Finally, critical analysis encourages a reflective stance on the integration of GenAI, prompting both students and educators to critically assess the benefits and limitations of these technologies in educational contexts. This concept calls for an examination of the broader societal, ethical, and pedagogical implications of GenAI, ensuring that its implementation aligns with educational goals and values. Through critical analysis, our research seeks to develop actionable knowledge that bridges the gap between the current state of digital teaching and learning and the ideal state that educators and policymakers aspire to achieve.

Methodology

This study employs an in-depth case study approach to examine the integration and impact of the GenAI tool. We selected five case studies of 6th semester BLS students to enable an in-depth exploration of students' interactions with and experiences of GenAI tools, prioritizing a detailed understanding of individual learning processes and contextual factors. Each student was treated as an individual case to capture the unique ways in which they engaged with ChatPDF during the preparation for the JCs. This approach allows us to capture nuanced insights into the complexities of how students engage with GenAI in their learning activities, which might be overlooked in larger cohort analyses focused on broader trends. Our research design integrates a sequential mixed methods design, combining both quantitative and qualitative data collection and analysis techniques, aiming to provide a holistic understanding of how students utilize GenAI tools and how these tools influence their learning activities (Braun et al., 2021; Small, 2011).

This study adopts a pragmatic epistemological approach, emphasizing the practical utility of ChatPDF as a tool for student preparation for JCs. The JC is framed within a social constructivist

context, where knowledge is co-constructed through dialogue and interaction during group discussions. The study explores how ChatPDF supports individual engagement with and understanding of scientific texts, which students then bring into collaborative discussions. While social constructivism provides a lens for understanding collective knowledge construction within the JC, pragmatism guides the evaluation of ChatPDFs practical impact on achieving learning objectives and enhancing preparation.

The framework applied in this study draws on perspectives outlined in the editorial 'Is AI Good for Agency?' (Stenalt & Hachmann, 2024), which emphasizes the interplay between educational technology and student agency. These editorial highlights the importance of understanding how agency is constructed in digital contexts and advocates for nuanced conceptualizations of how AI influences learning processes. Our framework incorporates key dimensions such as self-efficacy, agency, digital literacy, data use, and critical analysis, aligning with the editorial's call for research that addresses both psychological and practical competencies in students' interaction with AI **(Table 1)**. By applying this framework, we aim to bridge the gap identified in the research field, focusing on how GenAI can foster or challenge student agency in specialized educational contexts (Stenalt & Hachmann, 2024).

Table 1: Conceptual framework for analyzing student interaction with GenAI.

Category	Concept	Description
Psychological dimensions	**Self-Efficacy**	Students' confidence in their ability to successfully use GenAI tools like ChatPDF for learning.
	Agency	The capacity of students to take initiative and make autonomous decisions about their learning.
Practical dimension	**Digital Literacy**	The ability to navigate, evaluate, and use digital tools effectively in an educational context.
	Data Use	Skills in interpreting and leveraging AI-generated information for academic tasks.
	Critical Analysis	The ability to critically evaluate and reflect on AI-generated content to ensure reliability and relevance.

To be clear, the framework is not intended to promote certain ideals of digital teaching and learning. Rather, it aims to promote understanding of the ways GenAI tools extends purely cognitive investment on the student part, and of digital interactions. Additionally, it attempts to enable researchers and academic staff to critically reflect on the ways GenAI is configured in formal contexts of learning and develop actionable knowledge that bridges the gap between

the state–of–the–art and state–of–the–actual and obliges breakdowns in digital teaching and learning.

Study and participant context

This study was conducted as part of a JC integrated into a 6th semester course on evidence-based practice. The JC included six students, five of whom voluntarily participated in this study (Student A–E). Over six weeks, students attended three JC meetings, each focusing on a specific journal article. This was their first formal JC experience, although they had previously engaged with journal articles in earlier coursework.

During the JC, students took on specific roles to facilitate structured and interactive discussions. Some acted as presenters, summarizing the article by highlighting the research question, methodology, key findings, and implications. Others served as facilitators, moderating the discussion to keep the meeting focused and encouraging participation from all attendees. Additionally, some students assumed the role of reviewers, critically evaluating the article by identifying its strengths, weaknesses, and areas for further inquiry.

The aim of the JC was to prepare students for incorporating research findings into clinical decision-making during their upcoming placements. JCs followed a structured format, beginning with the presenters' summary of the article and concluding with group discussions based on key questions posed by peers.

Ethical considerations in data collection and participant recruitment

The methods employed were guided by the study's aim to explore the nuanced interactions between students and GenAI tools. The mixed methods design enabled triangulation of quantitative and qualitative data, ensuring a comprehensive understanding of the phenomena. Reflections on survey and interview design, voluntary case study participation, and the role of AI in the research process are included to enhance transparency and rigor.

Participation in the study was entirely voluntary, with all students fully informed about the purpose, methods, and potential implications of their involvement. Ethical considerations included obtaining informed consent, ensuring anonymity and confidentiality, and addressing the ethical implications of using AI tools in educational research. Risks, such as over-reliance on AI, were minimized, and participants retained the right to withdraw at any time without repercussions.

Observational and tracking methodologies

To assess student engagement with ChatPDF, we implemented both observational and tracking methodologies. Observational methods included direct observation of students during JC sessions to capture real-time interactions, behaviors, and engagement levels. This involved positioning trained observers in the classroom to systematically document student activities, interactions with the tool, and collaborative dynamics during discussions. In addition to direct observations, we utilized tracking tools embedded within ChatPDF to monitor students' usage patterns. This included logging the frequency and duration of interactions, the specific prompt features of ChatPDF used (e.g., question generation, summarization, annotation), and the nature of the documents accessed. These tracking metrics provided quantitative data on how students engaged with the tool over time.

To systematically analyze and categorize the interactions of students with ChatPDF, we developed a framework based on observations of student behavior and insights from the literature. Specifically, this framework is informed by Jin et al. (2023), who explore how AI tools support cognitive, metacognitive, and behavioral regulation, and Yang et al. (2023), who identify varying levels of engagement and critical thinking in students' use of GenAI tools (Jin et al., 2023; Yang et al., 2024).

The framework categorizes prompts into five distinct types — Explain, Summarization, Highlight, Assessment, and Analysis **(Table 2)**. Each category represents a distinct pattern in which students engage with the tool, thereby providing a comprehensive overview of how ChatPDF supports learning in a JC setting:

Table 2: Categorizing GenAI prompts

Prompt category	Description	Example
Explain	This category encompasses prompts where students seek detailed explanations or clarifications about specific concepts or sections of the academic texts. By using ChatPDF to explain complex ideas, students can enhance their understanding of intricate material, facilitating deeper learning and comprehension.	"Can you explain the main findings of this article in simple terms?"
Summarization	Under this category, we classify prompts that request concise summaries of longer texts or articles. ChatPDF's ability to condense information into shorter, more digestible segments helps students quickly grasp the main ideas and arguments presented in the literature, making it easier to manage and review extensive academic content.	"Summarize the methods section in 100 words."
Highlight	This category includes prompts where students ask ChatPDF to identify and emphasize key points or important sections within a text. By highlighting crucial information, the tool aids students in focusing on the most significant elements of the material, which is particularly useful for preparing for discussions and examinations.	"What are the three main arguments presented in this study?"
Assessment	Prompts that fall into this category involve the evaluation of students' understanding or the generation of questions for review purposes. ChatPDF can create questions based on the text, helping students test their knowledge and identify areas that require further study or clarification.	"What are the strengths and weaknesses of the methodology used?"
Analysis	This category is dedicated to prompts that require deeper critical thinking and examination of the text. Students use ChatPDF to break down arguments, compare different perspectives, and analyze the validity and significance of the research findings. This supports the development of critical analysis skills, which are essential for academic success.	"How does this study compare to the findings of [another study]?"

The student's chat transcript in ChatPDF was obtained, and each prompt was categorized. This approach allowed us to systematically assess how students utilize ChatPDF and to identify patterns in their engagement with the tool. By analyzing the frequency and context of each type of prompt, we aimed to gain deeper insights into the effectiveness of ChatPDF in facilitating various aspects of learning and academic discourse.

Surveys and interviews

Quantitative data were collected through a structured survey administered to all participating through SurveyXact® (Rambøll, Copenhagen, Denmark). The survey aimed to gather detailed information on students' initial perceptions, ongoing experiences, and overall satisfaction with the use of ChatPDF **(Table 3)**. Questions were designed to assess various dimensions of engagement, including cognitive, behavioral, and emotional aspects (Stenalt, 2022).

Table 3: Framework and response metrics for survey on evaluating ChatPDF in JCs.

Dimensions	Description	Question	Response options
Learning and critical thinking			**Each question is answered on a scale from 1 to 5, where 1 represents 'to a low extent' and 5 represents 'to a high extent'**
Skills, competencies	The practical abilities and specialized knowledge acquired and applied, enhancing overall effectiveness and proficiency.	To what extent were you able to apply your skills and competencies while using ChatPDF?	
Critical thinking	The process of analyzing and evaluating information objectively to make reasoned judgments and decisions.	To what extent were you able to engage in critical thinking when using ChatPDF?	
Creativity	The ability to generate original ideas and solutions, often by combining existing concepts in new and innovative ways.	To what extent were you able to express your creativity with ChatPDF?	
Engagement	The extent to which users actively interact and utilize, exploring their features and capabilities to enhance learning and achieve desired outcomes.	To what extent did you find the experience of using ChatPDF engaging?	
Agency			
Socialization	Interacting and forming relationships with ChatGTP to exchange ideas and collaborate.	To what extent did you find yourself interacting and collaborating with ChatPDF?	
Cognitive expressiveness	The ability to clearly articulate and convey complex thoughts, ideas, and knowledge through various forms of communication.	To what extent did you feel that you could express and share thoughts in ChatPDF (e.g. asking clarifying questions or elaborating contributions)?	
Emotional expressiveness	The capacity to express and communicate feelings and emotions effectively, often through verbal and non-verbal means.	To what extent did you feel that you could express and share thoughts in ChatPDF (e.g. asking clarifying questions or elaborating contributions)?	
Visibility	The degree to which one's work or contributions are noticeable and accessible to co-students within a given context.	To what extent did you experience that your participation or your contribution with ChatGTP was visible to others?	
Access of contributions	The access and refer to their own and others' contributions or work after the initial interaction, ensuring ongoing availability and utility of the information.	To what extent did you experience that you could access your own contributions afterwards (e.g. if you wanted to revisit an interaction with Chatpdf)?	
ChatPDF impact on future learning and engagement			
Activity	Likelihood of students continuing to use ChatPDF in the future. It seeks to understand their overall satisfaction with the tool and whether they found it valuable enough to incorporate into their ongoing studies.	To what extent would you use ChatPDF again?	
Utility	Influence regardering the range of strategies and approaches students consider when tackling academic tasks. Assesssment of whether the tool expands their choices or alters their decision-making process.	To what extent do you think ChatPDF will affect your action options?	
Learning	Perceived impact on the students' learning outcomes. It aims to measure how effectively the tool enhances their understanding of the material and supports their academic progress.	To what extent do you feel ChatPDF strengthens your learning?	
Motivation	Students' motivation and enthusiasm for completing academic tasks. It looks at how the tool may affect their drive to engage with and solve challenges in their studies.	To what extent do you feel that ChatPDF strengthens your motivation to solve a task?	

To complement the survey data and gain deeper insights, qualitative data were collected through in-depth semi-structured interview for each of the participating students (Braun et al., 2021; Leech et al., 2010). These interviews were conducted in a relaxed and open-ended manner to encourage students to share their experiences and reflections in detail.

Data interpretation and analysis

The sequential mixed methods design allowed for the integration of quantitative to explore further with qualitative data, providing a comprehensive view of the research findings (Curry et al., 2009; Leech et al., 2010). The quantitative survey results were also triangulated with the qualitative interview insights to validate the self-efficacy analysis of the students A-E. Data from surveys was collected in SurveyXact® (Rambøll, Copenhagen, Denmark) and exported to Microsoft Excel (v. 5.0.4213.42) where data assessment and analysis was conducted. All data from the open-ended questions in surveys were uploaded and analyzed in ALTAS.TI, where a combined inductive thematic coding was conducted to support the interview protocol (Clarke & Braun, 2013). Transcription of the interview was made using ATLAS.TI and NVIVO v12 automatic transcription tools. Transcript and audio were then re-heard and compared. Final transcripts were read through by two independent reviewers. Supported by the research questions of this study, a combined inductive and deductive iterative coding methodology was conducted synthesizing the final structure and themes.

Results and analysis

Student perception of their own academic proficiency

This study presents a detailed exploration of academic proficiency levels in the study cases of five students, identified here as Student A through Student E. The analysis focuses on multiple dimensions of self-efficacy, including both academic skills and personal belief systems. The findings are summarized in Table 4, which captures individual scores, as well as observed minimums, maximums, and average values across the dimensions studied and students. The dimensions assessed include mastery of actions, academic challenges, academic reading, academic interactions, belief in their own abilities and resources, and meeting expected goals.

Table 4: Students' perceptions of academic proficiency. Data from questionnaire showing detailed breakdown of self-efficacy perceptions across six key dimensions for five individual students (Student A to Student E). Self-efficacy scores range from 1 (lowest) to 5 (highest).

Dimensions	**Student A**	**Student B**	**Student C**	**Student D**	**Student E**	Observed minimum	Observed maximum	Average
Mastering actions	4	4	5	2	3	2	5	3,6
Mastering academic challenges	4	4	4	2	4	2	4	3,6
Mastering academic reading	3	4	5	2	4	2	5	3,6
Mastering academic interactions/discussions	3	3	5	1	3	1	5	3,0
Belief in own abilities and resources	3	2	4	1	2	1	4	2,4
Meeting expected goals	4	4	5	2	4	2	5	3,8
Over-all self-efficacy	**3,5**	**3,5**	**4,7**	**1,7**	**3,3**			

We see a variability in self-efficacy perceptions among the five students. For instance, Student C consistently reported higher self-efficacy across all dimensions, particularly excelling in 'Mastering Academic Reading' and 'Meeting Expected Goals,'. This was also verified in the interviews where one student stated:

> "I feel confident in my ability to understand and engage with academic texts and academia in general, and I always meet the goals I set for myself and that are set by the education."

Conversely, Student D displayed notably lower self-efficacy, with the lowest scores in 'Mastering Academic Interactions/Discussions' and 'Belief in Own Abilities and Resources.' The majority of students, however, identified themselves a little over average in terms of self-efficacy. One student noted:

> "I can manage the coursework and contribute to discussions, but I see myself as performing at a typical level compared to my peers."

Analyzing student practical dimension with ChatPDF: Case-by-Case prompt analysis

While most students were familiar with GenAI, their experience with these tools had been limited to everyday tasks rather than academic applications. As one student noted:

> "Most of us knew about GenAI but had only used it for daily activities like writing emails or coming up with witty responses to texts. It helped me avoid the classic 'Sorry for the late reply' excuse!"

The analysis of student interactions with ChatPDF preparation for each of the three JC sessions revealed distinct patterns in the usage of prompt activities for each student (A-E). Each students' prompts were categorized into the five primary categories: Explain, Summarization, Highlight, Assessment, and Analysis (**Figure 1**). The distribution of these categories provides insights into how students of varying academic strengths and needs engaged with the tool (Crompton & Burke, 2023).

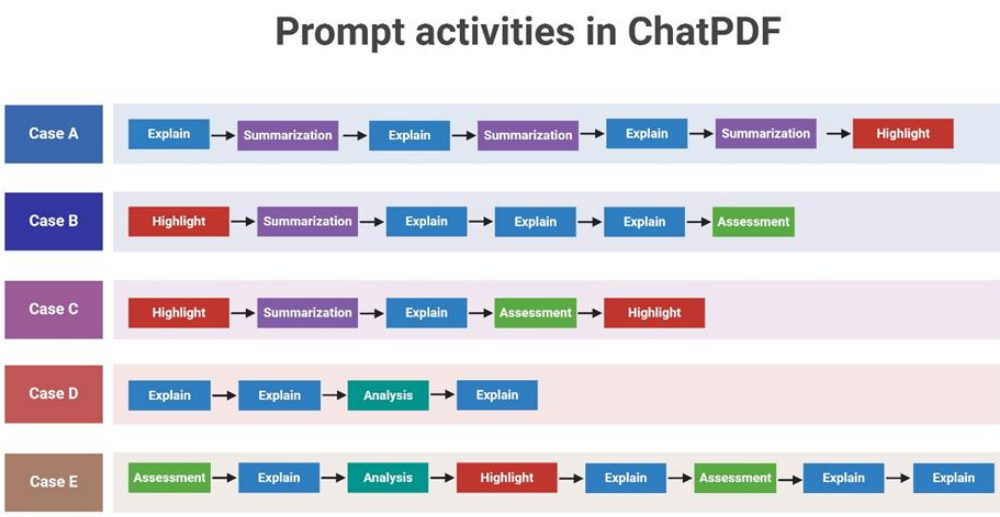

Figure 1: Pattern of prompt activity in ChatPDF of student A-E for preparation for JC sessions. Distribution of prompt activities in ChatPDF across student A-E. Prompt patterns are categorized by function: Explain (blue), Summarization (purple), Highlight (red), Assessment (green), and Analysis (teal). The prompts are organized by case and displayed in chronological order.

Case A demonstrated a frequent use of Explain and Summarization prompts, always finished off with a Highlight prompt. This suggests that the student relied heavily on ChatPDF for both detailed explanations and concise summaries, which helped in understanding different aspects and managing the academic material.

Case B showed a high focus on Explain prompts. This pattern indicates that the student primarily used ChatPDF to gain deeper insights through explanations and to emphasize key points, while also occasionally testing their understanding.

Case C was notable for its balanced use of prompts: Highlight, Summarization, Explain, and Assessment prompts. This suggests that the student employed a diverse approach, using

ChatPDF to identify key information, summarize content, and assess their understanding of the material.

Case D showed a strong focus on Explain prompts for different aspects of the articles. However, a closer analysis revealed that these prompts were almost exclusively used for translation purposes. This suggests that the student did not engage with the tool to explore content critically or evaluate findings, but rather relied on it to overcome language-related barriers. As a result, the student's use of ChatPDF was primarily instrumental and surface-level, aimed at basic comprehension rather than deeper academic analysis.

Case E was characterized by a predominant use of Explain prompts, along with some Assessment, Analysis, and Highlight prompts. This suggests that the student engaged deeply with the material, seeking detailed explanations, and frequently assessing their understanding, while also conducting analysis and highlighting key information.

Students generally employed ChatPDF to clarify ambiguous points in academic articles, extract key insights, and summarize content, which was also confirmed by interview data. However, they emphasized that mastering the use of GenAI is crucial. A recurrent theme in their feedback was the necessity for enhanced prompt-writing skills. As one student remarked:

> "Understanding how to write a good prompt could really improve how I use ChatPDF. Currently, it feels like a lot of trial and error to get the responses I need."

Another student noted:

> "It would be helpful to know what directions you can take when using GenAI."

Additionally, another student highlighted the importance of understanding the underlying mechanisms of GenAI, stating:

> "It is important to learn about how language models extract information and how GenAI works in general."

Furthermore, a common observation among students was the necessity of having a solid foundation in reading and working with scientific articles prior to utilizing tools like ChatPDF. As one student explained:

> "It is important that, as a student, you have the foundation for how to read and work with scientific articles before using ChatPDF. Learning how to do it correctly before using GenAI is crucial for being able to assess whether ChatPDF is doing it correctly."

An additional finding was that Case D, which used the tool for the longest period and with the fewest prompts, struggled with translation and did not utilize the tool effectively. This student also scored low in self-efficacy, suggesting that individuals with lower self-efficacy may not intuitively grasp how to use these tools. In the interview with Student D, it became clear that the student used the tool merely to translate the articles. This highlights a broader issue: those who lack confidence in their abilities may find it challenging to leverage GenAI tools efficiently.

Student interactions with ChatPDF: Insights into both the psychological and practical dimensions

In this section, we present a comprehensive analysis of the data collected from student surveys and interviews, focusing on the students' perception of their interactions ChatPDF in a JC setting. The combination of quantitative survey results and qualitative insights from interviews provides a robust understanding of how ChatPDF influences students experience with JC. This analysis not only highlights the overall effectiveness of ChatPDF but also sheds light on the diverse ways in which students utilize the tool.

In **Figure 2**, we see a strong consensus among students regarding the practical dimension of ChatPDF. The figure illustrates generally positive perceptions among students regarding ChatPDFs ability to support their skills and competencies (average score = 4.0), foster creativity (4.0), critical thinking (3.8), and promote engagement (3.8). Although not all students selected the highest possible ratings, the scores suggest a consistent pattern of moderate to high appreciation. These results indicate that students perceived ChatPDF as a tool that could meaningfully support their academic engagement and thought processes in JC.

Figure 2: Student perceptions of the practical dimensions of ChatPDF (n=5). The figure illustrates the average scores for each aspect of students' perceptions regarding the use of their skills, competencies, critical thinking, creativity, and engagement while using ChatPDF. The response options range from 1, indicating the lowest degree of perceived support, to 5, representing the highest degree.

Despite these generally positive ratings, several students voiced concerns in the interviews regarding the tool's accuracy and its potential effects on their engagement with the material:

> "I've noticed that ChatPDF sometimes adds details that aren't actually in the articles I upload. It can be confusing when I rely on the tool for accurate information and end up with inaccuracies."

Another student reported:

> "In one of my assignments, ChatPDF provided several facts that were not in the source material. I had to double-check everything manually because I couldn't trust the tool to be accurate."

Additionally, a student expressed concern about the potential impact of the tool on deep engagement, stating:

> "I'm worried that if I rely too much on uploading articles and letting ChatPDF do everything, I might not engage deeply with the material and could end up forgetting what I learned."

The agency of students' experience with ChatPDF, which assesses the extent to which students felt they could take initiative, make autonomous decisions, interact, and form relationships to exchange ideas and collaborate, is illustrated in **Figure 3**.

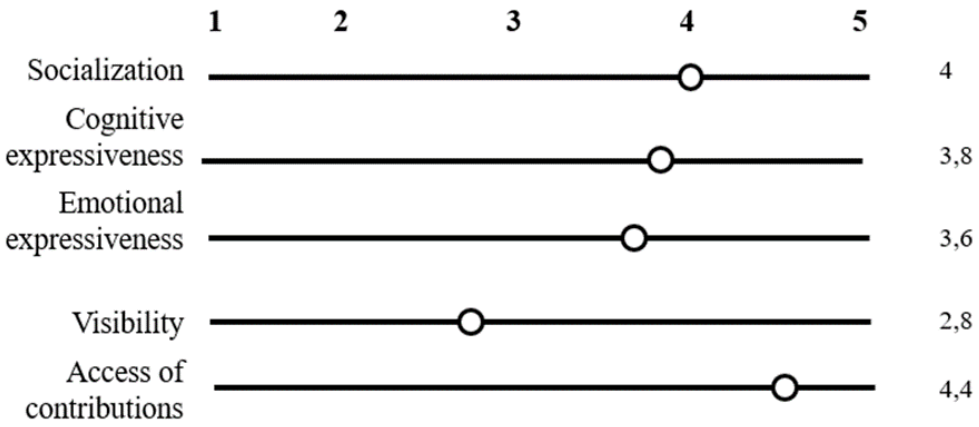

Figure 3: Student perceptions of agency with ChatPDF (n=5). This figure presents the average scores for students' perceptions of ChatPDF across five key dimensions: socialization, cognitive expressiveness, emotional expressiveness, visibility, and access to contributions. The scores range from 1, representing the lowest degree of perceived support, to 5, indicating the highest degree.

This high score indicates that students found ChatPDF to be quite effective in promoting social interaction and collaboration. The tool appears to provide a supportive environment for users

to engage with one another, share ideas, and build relationships. The students called ChatPDF valuable as a third-party resource in group contexts. It often served as a mediator to facilitate discussions, enhance collaboration, and aid in resolving disputes and clarifying issues. For example, one student observed:

> "When our group had different opinions on a topic, we would turn to ChatPDF to provide an unbiased summary or clarification. It helped us see a different perspective and make more informed decisions."

Similarly, another student mentioned:

> "We often used ChatPDF when we couldn't agree on certain points. It acted as a third party that we could consult. Me and my co-student were like Maverick and Goose and ChatPDF was the F-14 Tomcat."

Cognitive expressiveness and communication, which measures the ability of users to clearly articulate and convey complex thoughts and ideas, received a rating of 3.8. This score indicates that students generally found ChatPDF to be a useful tool for expressing complex ideas, though it may not have fully met all their expectations.

Visibility, which refers to how noticeable and accessible one's work or contributions are to co-students, received the lowest rating of 2.8. This score indicates a concern among students regarding the visibility of their contributions within the context of the tool. Students' engagement and sense of participation may be negatively affected when they feel that their contributions are not sufficiently visible.

The highest rating, 4.4, was given to the dimension of access to contributions, which assesses how well users can access and refer to their own contributions. This high score indicates that students found ChatPDF very effective in maintaining access to past interactions and ensuring that information remains available and useful over time. This feature is particularly important for educational and collaborative environments, where the ability to revisit and reflect on previous contributions.

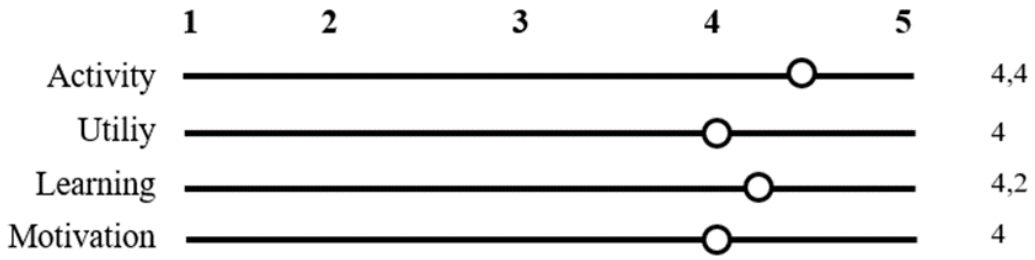

Figure 4: Student Perceptions of future use of ChatPDF: Activity, Utility, Learning, and Motivation (n=5). The scores, ranging from 1 (lowest degree) to 5 (highest degree), illustrate how students evaluate ChatPDFs effectiveness in encouraging ongoing use (activity), influencing their future academic strategies (utility), enhancing their learning outcomes (learning), and boosting their motivation to engage with academic tasks in the future.

The dimension of Activity, which measures the likelihood of students continuing to use ChatPDF in the future received a high rating of 4.4 (**Figure 4**). This strong rating suggests that students found ChatPDF valuable and are inclined to incorporate it into their ongoing studies, a sentiment that was also clearly reflected in the interviews. The high score reflects a positive reception, indicating that the tool is perceived as a beneficial addition to their academic toolkit. This result highlights the tool's potential for sustained use, suggesting that students see ongoing value in its features for their educational needs. Utility examines how ChatPDF influences the range of strategies and approaches students consider when tackling academic tasks, as well as its impact on their decision-making processes. With a rating of 4, the results indicate that students believe ChatPDF has a significant influence on their academic strategies and choices. This rating suggests that the tool is effective in expanding students' options and altering their decision-making processes, thereby playing a meaningful role in how they approach their studies. The score reflects a solid endorsement of the tool's usefulness in academic planning and strategy formulation.

The learning dimension assesses the perceived impact of ChatPDF on students' understanding of material and academic progress. The rating of 4.2 indicates that students feel the tool positively enhances their learning outcomes. This score reflects that ChatPDF is viewed as a helpful resource for deepening their understanding of course content and supporting their academic success. The slightly lower score compared to Activity suggests that while the tool is beneficial, there may still be room for improvement in maximizing its impact on learning outcomes. Motivation considers how ChatPDF affects students' enthusiasm and drive to complete academic tasks, particularly in how it influences their approach to solving challenges. This dimension received a rating of 4, indicating that students feel ChatPDF

strengthens their motivation to engage with and complete academic tasks. The score suggests that the tool has a positive impact on students' willingness to tackle challenges, contributing to a more proactive approach to their studies.

Discussion

This study explored the integration of ChatPDF, a GenAI tool, into JC sessions within BLS education. Focusing on key domains — affordance, self-efficacy, digital self-development, data uses, and critical analysis — we aimed to understand how this tool impacts student engagement, learning, and analytical skills. The findings reveal significant insights into the practical implications and pedagogical considerations of embedding GenAI tools like ChatPDF into educational settings.

Insights from prompt activity analysis

The analysis of student prompt activities with ChatPDF provides valuable insights into how GenAI tools can support diverse learning needs and strategies within a JC setting. By examining the varied use of prompt categories across different cases, several implications for student agency, digital literacy, critical thinking, and potential areas for improvement emerge. Some students, such as those in Cases A, B, D, and E, heavily rely on Explain prompts to seek detailed clarifications, while others balance their use of Summarization, Highlight, and Assessment prompts, as seen in Cases B and C. This diversity in engagement strategies suggests that ChatPDF can cater to different learning styles, offering both in-depth explanations and tools for efficient content management. The frequent use of Explain and Assessment prompts indicates that students are actively use the tool to understand the material deeply and validate their comprehension.

However, an important consideration is that over-reliance on certain features, such as Summarization and Highlight prompts, may lead to a more superficial interaction with the material. Students could bypass thorough reading and critical analysis of primary texts, undermining the depth of their engagement. Educators should be aware of this risk and guide students to use ChatPDF as a supplementary tool, rather than replacing deep engagement with primary sources. This potential risk is further discussed in more detail in the following section. Despite these concerns, ChatPDFs ability to support data use and digital literacy must be considered, as students interact with AI-driven tools to process complex scientific texts.

Risks of superficial engagement

One significant downside, seen in this case study, is the risk of superficial engagement with academic material. ChatPDFs ability to summarize and generate questions may lead students to rely on these features for quick answers rather than engaging deeply with the primary texts. In a JC setting, where critical analysis and in-depth discission of scientific literature are paramount, this reliance can undermine the quality of discourse. Students may bypass a thorough reading of the full text, missing out on nuanced arguments and details essential for meaningful discussion and critique.

Also, ChatPDFs summarization and question-generation capabilities might inadvertently reduce students' opportunities to develop self-efficacy and critical analysis in evaluating scientific studies independently. In a JC, the process of critically analysis and synthesizing complex information is crucial. If students become accustomed to receiving pre-digested content from ChatPDF, they may not practice the cognitive processes required to independently assess the validity, reliability, and significance of scientific studies. This can hinder their ability to engage in rigorous debate and analysis, which are central to the objectives of JC activities. The use of ChatPDF also introduces the risk of over-reliance on AI-generated recommendations and insights. This can lead to a diminished capacity for independent judgment and a reduced ability to identify and address potential biases or gaps in the AI-generated content. Over-reliance on AI can also discourage students from developing their own analytical frameworks and methodologies for evaluating research (Crompton & Burke, 2023; Nkomo et al., 2021) .

Another critical issue is the potential for GenAI tools to exacerbate existing inequities in education. Digital literacy may vary among students, and some may struggle to use ChatPDF effectively, potentially widening the gap between high and low proficiency students. Access to GenAI tools, like ChatPDF, may be uneven, with some students or institutions lacking the necessary resources to implement these tools effectively, as seen in this study. This digital divide can create disparities in educational opportunities and outcomes, where students with access to GenAI tools receive enhanced learning support, while others are left behind. Ensuring equitable access to technology and related training is essential to avoid widening the gap between different student groups.

Disparities Between High and Low Proficiency Students

The experimental exploration of GenAI tools into educational settings holds focus of enhancing learning and engagement (Crompton & Burke, 2023). However, this study also highlights the

risk that GenAI tools could disproportionately benefit high-proficiency students while exacerbating challenges for those who require additional support. Students with strong academic skills and high self-efficacy are more likely to harness the full potential of ChatPDF, using it to deepen their understanding of scientific concepts and accelerate their learning. For these students, ChatPDF can serve as a powerful tool that enhances their agency in navigating academic materials and discussion. This underlines the importance of educators providing targeted support to student who struggle with the tool.

In contrast, students requiring additional support may struggle with ChatPDF, widening existing educational gaps. Some students who struggled found it difficult to craft effective prompts or interpret AI-generated summaries, hindering their ability to engage deeply with the material. Over-reliance on ChatPDF could result in lack of agency, preventing students from critically engaging with complex texts. This could further entrench their difficulties in understanding complex concepts and hinder their overall academic progress. GenAI tools like ChatPDF operate based on algorithms and pre-set functionalities, which do not account for the individual learning needs and challenges of each student (Crompton & Burke, 2023; Xia et al., 2024). While these tools offer standardized support, they may fail to address the specific challenges or learning gaps of students requiring additional support. This suggest that digital literacy, agency, and self-efficacy play a crucial role in determining how effectively students integrate AI tools into their learning process.

Agency and the role of autonomy in JC

While this study extensively discusses self-efficacy, the closely related concept of agency warrants further elaboration. Agency, as defined in our analytical framework, refers to students' capacity to act autonomously and make informed decisions in their learning process (Klemencic, 2017; Stenalt & Hachmann, 2024). Our findings suggest that GenAI tools like ChatPDF can both enhance and challenge students' sense of agency.

For high-performing students, ChatPDF appeared to support agency by enabling them to independently set goals, assess understanding, and tailor their learning strategies. These students demonstrated initiative in exploring various prompt types and using ChatPDF strategically to enhance their contributions in JC discussions. This reflects an active engagement with their learning environment, reinforcing both agency and self-efficacy.

In contrast, for students with lower self-efficacy, agency was more constrained. For example, Student D primarily used ChatPDF for translation purposes and exhibited limited initiative in exploring the tool's broader functionalities. This suggests that while GenAI can scaffold student

learning, it may also risk reducing agency if students adopt a passive role, relying on the tool to do the work rather than actively shaping their engagement.

The presence or absence of agency among students is thus a crucial lens for understanding how GenAI shapes educational experiences. In professional education settings such as Biomedical Laboratory Science, where independent decision-making and critical judgment are essential, fostering student agency should be a pedagogical priority. Educators must therefore not only provide access to GenAI tools, but also actively support students in developing the competencies and confidence to use these tools in ways that reinforce their autonomy and critical thinking.

Implications for teaching practices

The integration of GenAI tools also has implications for the role of educators. Educators must adapt to new technologies and incorporate them into their pedagogical practices effectively. This requires ongoing professional development and support, particularly in promoting digital literacy, self-efficacy, and critical analysis among students, which may not always be readily available. Additionally, there is a risk that educators might rely too heavily on GenAI tools, potentially diminishing their role in guiding and mentoring students. It is crucial to ensure that technology complements rather than replaces the human elements of teaching, such as personalized feedback, empathy, and encouragement. Moreover, clear guidelines and policies must be established to address ethical and privacy concerns, ensuring that data is handled responsibly and transparently (Vedersø et al., 2024). Students have voiced a clear preference for embracing GenAI rather than banning it, underscoring the need for educational institutions to adapt and support the effective use of these tools:

> "It is important that GenAI becomes an integrated part of education and not just gets banned. But in that context, it is also important to learn how to use it and how to use it in the right way. GenAI is here to stay, and therefore, educational institutions should embrace it, as we won't be able to avoid it."

Educators should also consider balancing the use of GenAI tools with other pedagogical approaches that cater to diverse learning needs (Crompton & Burke, 2023). Incorporating varied instructional methods, offering one-on-one support, and fostering a collaborative learning environment can help bridge the gap and ensure that all students benefit from technological advancements.

Limitations of the case study

The findings of this study are limited by the small sample size (n=5), which restricts the generalizability of the results. While the in-depth exploration of these five cases offers valuable insights into student interactions with GenAI tools, it is important to note that these results may not be representative of a broader student population. The decision to work with a small cohort prioritized depth over breadth, enabling a detailed analysis of individual learning experiences. However, this choice also limits the ability to make broader generalizations about student interactions with GenAI tools. A larger sample size would enhance the external validity of the study, providing a more comprehensive understanding of how these tools impact a wider range of learners. Further research with larger sample sizes is needed to validate the findings and assess the broader applicability of these results to different educational contexts.

Conclusion

This study investigated how students with varying academic proficiency levels engage with ChatPDF, a GenAI tool, in preparation for JC sessions. The findings show significant disparities in how students exercise agency, defined here as the capacity to act autonomously, and make informed decisions in their learning processes. High-performing students demonstrated high levels of agency by formulating diverse prompt types—such as Explain, Assessment, and Highlight—to strategically navigate scientific texts, monitor comprehension, and actively shape their contributions to academic discussions. These students used ChatPDF to extend their analytical capacity, indicating that GenAI can serve as a scaffold for self-directed learning when integrated intentionally.

In contrast, lower-performing students often displayed limited agency. For instance, some relied almost exclusively on translation functions or superficial summarization prompts, with little evidence of exploratory use or independent critical engagement. This constrained use not only limited their conceptual understanding but also reduced opportunities to develop judgment and analytical reasoning—core competencies in JC settings. Such patterns suggest that GenAI tools, when used uncritically, risk reinforcing passive learning behaviors and diminishing students' sense of ownership over the learning process.

The study also identified that while ChatPDF can support digital literacy and self-efficacy—particularly among academically confident students—it may simultaneously inhibit these domains among those with less experience or confidence. Over-reliance on summarization features was associated with a decline in critical engagement, as students bypassed close reading and nuanced interpretation of primary literature. Furthermore, unequal abilities to craft

effective prompts or interpret AI-generated outputs point to a digital divide that may exacerbate existing academic inequalities.

Notably, across proficiency levels, students expressed a strong desire to continue using ChatPDF and similar GenAI tools in future academic tasks. They reported feeling more motivated and confident when such tools were available, viewing them as valuable companions in managing and making sense of complex scientific texts. This perceived usefulness highlights the motivational potential of GenAI and underscores the urgency of integrating these tools into higher education with pedagogical care and intentional scaffolding.

These findings suggest that the integration of GenAI tools must go beyond technical access. Educators must provide targeted support to cultivate student agency, critical thinking, and digital competencies. Used thoughtfully, ChatPDF can motivate and empower students; used uncritically, it risks eroding foundational academic skills. The pedagogical challenge lies in fostering conditions under which GenAI tools augment, rather than replace, students' capacity for autonomous and reflective academic engagement.

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