
Sustainable learning practices in higher education through conversational AI tools: A case study of ESEF Oujda

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Abstract

The emergence of Society 5.0 has accelerated the integration of advanced technology and artificial intelligence into all aspects of human life to foster sustainability and inclusion. This vision especially impacts education by aiming to improve the quality of life for all learners. In this context, digital transformation and collaborations between students and technologies, such as conversational AI, are increasingly shaping students' sustainable learning practices. While subjects like students' perceptions, academic performance, or ethical concerns surrounding AI use are being widely examined, the connection between conversational AI tools and Sustainable Learning in Education (SLE) remains underexplored. Ben-Eliyahu (2021) described SLE through four aspects: renewing and relearning (updating and adapting knowledge), independent and collaborative learning (self-driven and group-based acquisition), active learning (engagement with material), and transferability (applying knowledge to new contexts). Aligning with the United Nations Sustainable Development Goal 4 (quality education), this study examined how conversational AI tools impact the sustainable learning practices of ESEF Oujda students. To achieve this aim, the study employed a mixed-methods approach, combining a survey to measure conversational AI use and SLE components with a correlational T-test, and a qualitative writing task to capture habit changes. Understanding how conversational AI tools support or hinder those dimensions can provide valuable insights for educators, policymakers, and curriculum designers seeking to integrate AI responsibly and effectively into higher education.

Keywords: conversational AI tools, Sustainable Learning in Education (SLE), higher education, AI responsibility and efficiency

1. Introduction

In the context of global climate change, sustainability has become a primary focus among researchers, particularly within the educational sector, which is crucial for societal progress. Consistent with Goal 4 of the United Nations Sustainable Development Goals, “Quality Education” (UNESCO, 2024), the integration of Artificial Intelligence (AI) in education has expanded considerably in recent years. This expansion has significantly transformed the way students engage with learning materials across all educational levels, from early childhood to higher education (Crawford, Allen, Pani, & Cowling, 2024; Yang, 2024).

Nevertheless, the intersection of AI use and sustainable development in education presents several challenges, particularly regarding AI’s impact on sustainable learning. While numerous studies have examined AI integration in education and others have explored sustainable education, limited research has focused on the effects of conversational AI tools on sustainable learning practices. Therefore, the present study investigates the impact of conversational AI tools on sustainable learning practices among students at the Higher School of Education and Training (École supérieure de l’Éducation et de la Formation) (ESEF) in Oujda, Morocco.

This research is based on Ben-Eliyahu’s (2021) framework, which conceptualizes sustainable learning in education (SLE) through four dimensions: renewing and relearning (updating and adapting knowledge), independent and collaborative learning (self-driven and group-based acquisition), active learning (engagement with material), and transferability (application of knowledge to new contexts).

2. Conceptual frameworks

As technological innovation accelerates, artificial intelligence has become a major force in modern learning environments. AI enables computer systems to perform tasks that typically require human intelligence, such as learning, problem-solving, and decision-making. Recently, AI has transformed many areas of human activity, with conversational agents showing particular promise for advancing education and training.

According to Vaidyam, Wisniewski, Halamka, Kashavan, and Torous (2019), conversational agents, including chatbots, chatterbots, and digital assistants, are computer programs designed to interact automatically with humans through speech, text, or both. Further supporting this, SeyedAlinaghi, Abbaspour, and Mehraeen (2024) explain that AI conversational tools imitate

human-like behavior. Moreover, Hackett (2023) observes that these agents engage in conversations that foster openness and reduce users' hesitation or fear of stigma.

Building on the emergence of conversational agents, conversational AI has evolved from early rule-based programs, such as ELIZA (Weizenbaum, 1966), which relied on pattern matching to simulate conversation. Today, contemporary generative transformer-based models (such as GPT-3 and ChatGPT) and multimodal systems (such as Google/DeepMind's Gemini) represent significant advances. This progression demonstrates a shift from rule-based to data-driven learning and from sequence models to Transformer architectures (Vaswani, Shazeer, Parmar, Uszkoreit, Jones, Gomez, & Polosukhin, 2017).

As a result, AI has moved beyond basic chat interfaces and now encompasses multimodal agents capable of reasoning, tool use, and managing extended contexts. Such advancements have substantially improved conversational fluency and adaptability, thereby broadening AI's potential to support youth learning.

Accordingly, artificial intelligence supports Goal No. 4 of the UN Sustainable Development Goals, Quality Education, by enabling individualized learning, automating educational processes, and expanding global access to knowledge. Sustainable development in education aims to ensure high-quality, accessible, and inclusive education for all. Therefore, AI holds considerable potential to enhance accessibility, efficiency, and inclusiveness in sustainable educational development.

In this vein, Sustainable Learning in Education (SLE) refers to the role that educational environments play in contributing to global sustainability. In this context, 'sustainable learning' means learning that is designed to endure over time and adapt to evolving societal and environmental demands. It is content-specific, imparting knowledge and understanding relevant to a sustainable world. As an educational philosophy, sustainable learning emphasizes curriculum design, instructional strategies, and learning techniques. It equips students with the knowledge and skills necessary to learn effectively in diverse learning environments, including constructivist settings (where learners build understanding through experience) and contextual settings (where learning is tied to real-world situations) (Figure 1).

Sustainable Learning in Education aims to equip students with the competencies needed for self-reinvention (Ben-Eliyahu, 2021). Accordingly, Ben-Eliyahu (2021) described SLE through four aspects: renewing and relearning (continuously updating and adapting one's knowledge),

independent and collaborative learning (learning achieved alone or through group interaction), active learning (engagement with material rather than passive absorption), and transferability (the ability to apply knowledge to new and varied contexts).

According to Ben-Eliyahu (2021), renewing and relearning in SLE, the first component of his concept of SLE, centers on the ongoing assessment and adaptation of knowledge and strategies. Here, 'renewing and relearning' means that learning is viewed as a renewable resource: it requires deliberate reflection on what is known, what is outdated, and what needs updating through innovative approaches. Just as the earth's resources must be reassessed and renewed, so too must one's learning. This involves not only evaluating grades or scores but also engaging in active self-reflection about current knowledge and future needs.

By monitoring their progress and identifying gaps between understanding and objectives, students ensure the continual renewal and relevance of their knowledge. Furthermore, SLE involves both independent and collaborative learning. 'Independent learning,' also known as being an autodidact, involves identifying what to learn and finding reliable sources of information to support that learning. 'Collaborative learning' occurs in groups or through interactions focused on the same or similar topics (Ben-Eliyahu, 2021). Balancing both approaches helps students seek out social support or scaffolding as needed.

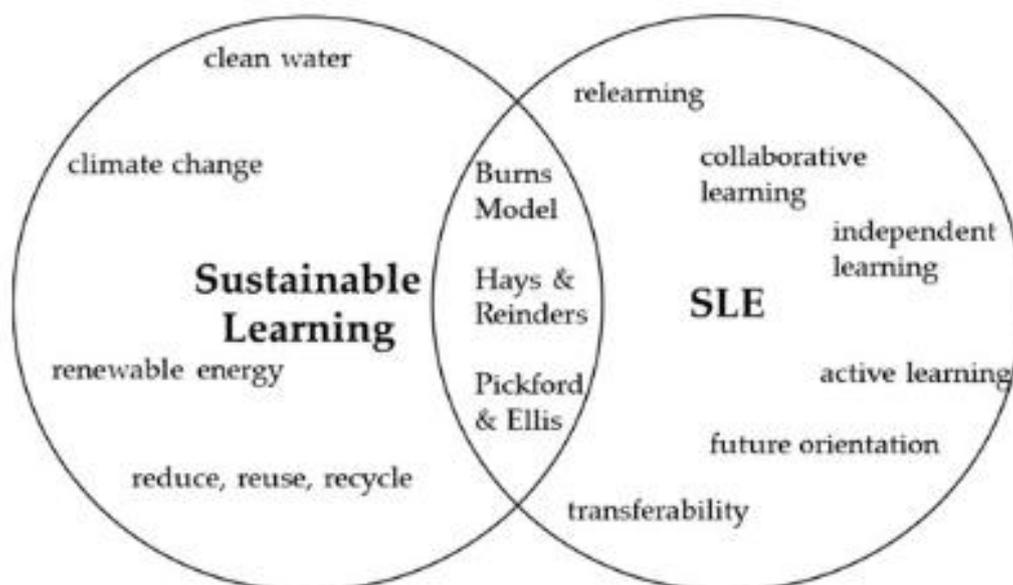


Figure 1. Schematic non-comprehensive presentation of overlaps and differences of sustainable learning and sustainable learning in education (SLE) (Ben-Eliyahu, 2021)

The third component of SLE is the notion of active learners, who monitor their progress through a feedback loop in which they evaluate their progress, identify remaining tasks, and make necessary adjustments to sustain effective learning. Such learners take the initiative to regulate and maintain aspects related to the learning task. They actively seek and identify what needs to be learned, what strategies are effective, and how specific outcomes are achieved. These manifestations are elements of SLE that are likely to transfer beyond the classroom (Ben-Eliyahu, 2021).

Additionally, he defined Transferability in SLE as the ability to apply familiar strategies, processes, or skills across different domains or contexts. Transferability across contexts involves utilizing skills acquired in one setting, such as school, in other environments, including work or home. The transfer of learning strategies and processes is particularly important during significant life transitions, such as transitioning from kindergarten to elementary school, from primary to secondary education, or from college to the workforce. These skills include planning, emotion regulation, attention control, and participation in social behaviors.

The proposed definition of SLE by Ben-Eliyahu (2021) deepens our understanding of ways to support learners' independent and active learning, which can adapt to diverse life demands and global circumstances. It offers a framework for identifying the strategies and processes essential for lifelong learning, including preparing for unforeseen challenges. SLE emphasizes sustaining learning skills as a resource, rather than focusing solely on specific content. Accordingly, SLE outlines strategies to promote self-sustaining learning through continuous renewal and independent relearning.

SLE also includes collaborative learning. It encourages active learning with a future orientation. SLE helps transfer learning strategies across various domains and changing life circumstances. This framework suggests that traditional learning models, which rely on face-to-face interaction with instructors and peers, may not adequately support SLE. To support sustained learning in a dynamic world, learners should engage in problem-solving experiences as a key part of formal education.

3. Materials and Methods

The objectives of the present study and the characteristics of the collected data necessitated a mixed-methods approach. Accordingly, the research combined a survey to assess the use of conversational AI tools and SLE components, which were analyzed using a correlational t-test, alongside a qualitative writing task to document changes in participants' habits. An explanatory

sequential mixed-methods design was employed, with a primary focus on the quantitative component, which did not involve manipulating variables or inferring causality. The qualitative phase was strategically employed to provide deeper insight into unexpected, significant, or complex statistical patterns (Fetters, Curry, & Creswell, 2013).

3.1. Research context

The present study investigated the effects of conversational AI tools on sustainable learning practices among ESEF Oujda students, with particular emphasis on the S1 Math G2 cohort. This group consisted of approximately 54 students aged 19 to 22, representing both male and female participants.

3.2. Research questions

In alignment with the aim to examine the impact of conversational AI tools on the sustainable learning practices of ESEF Oujda students, this study addresses the following research questions:

- 1) To what extent do students at ESEF Oujda employ conversational AI tools for academic purposes, with particular attention to the frequency, duration, and nature of these tasks?
- 2) To what extent do these students update and expand their knowledge, engage in independent and collaborative learning, practice active learning, and transfer skills and competencies across tasks?
- 3) How is the use of conversational AI tools associated with indicators of sustainable learning?
- 4) What are students' perceptions of the impact of conversational AI tools on their learning habits and academic integrity?

3.3. Instruments

3.3.1. *Conversational AI tools use Test*

The assessment of conversational AI tool usage comprised three components: frequency, duration, and purpose. Frequency was measured on a scale from 1 (never) to 5 (daily) to determine how often students utilized conversational AI tools. Duration referred to the average time spent per session, categorized as less than 15 minutes, 15–30 minutes, 30–60 minutes, or more than 60 minutes, and was also rated on a scale from 1 to 5. The purpose component evaluated the use of conversational AI tools across five areas: reading, writing, listening,

speaking, and grammar, with one point assigned to each area. Therefore, the total score, derived by summing these components (frequency, duration, and purpose), represents the extent of students' use of conversational AI tools.

3.3.2. Sustainable Learning Practices Assessment

The second variable in this study, sustainable learning practices, was measured using an instrument developed according to Ben-Eliyahu's (2021) framework. This framework defines sustainable learning environments (SLE) through four dimensions: renewing and relearning (updating and adapting knowledge), independent and collaborative learning (self-driven and group-based acquisition), active learning (engagement with material), and transferability (application of knowledge to new contexts). The instrument consisted of four sections: Renewing and Relearning, Independent and Collaborative Learning, Active Learning, and Transferability. Each section contained four statements rated on a five-point Likert scale from 1 (Strongly Disagree) to 5 (Strongly Agree). The overall SLE score was computed as the mean of all 16 items, with higher scores indicating stronger sustainable learning behaviors.

3.3.3. Ethical Considerations and Academic Integrity

Consent procedures, data anonymization, and the sensitivity associated with academic misconduct were addressed. The protocol for managing disclosures of cheating was specified. Additionally, the potential influence of ESEF's policy context on participant honesty was considered.

3.4. Data Analysis Procedures

After manual correction of the two tests, descriptive statistics were used to summarize and organize the data. Measures of central tendency (mean) and measures of dispersion (standard deviation) were calculated. All statistical analyses were performed using SPSS (Statistical Package for Social Sciences), which enabled systematic organization of participants' scores for both tests.

To examine the relationship between the two key variables, the Pearson product-moment correlation (PPMC) was used. This parametric test is appropriate for assessing the significance of associations between two quantitative variables measured at the interval or ratio level. The Pearson correlation produces the coefficient "r," which ranges from -1 to 1.

Subsequently, thematic analysis was conducted to examine the collected qualitative data, specifically the students' written opinions. Braun and Clarke (2006) outline a six-step procedure: familiarization with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. This approach ensures that the findings are systematic and credible and effectively complement the quantitative results in this mixed-methods study.

4. Results and Discussion

A total of 54 completed surveys were collected after being shared with participants via WhatsApp to investigate the relationship between the use of conversational AI tools and sustainable learning practices. The subsequent figures, generated using SPSS, present frequency, descriptive, and correlational statistics.

Table 1 indicates that 70.4% of students regularly use conversational AI tools, while 16.7% report infrequent use. These findings align with previous research demonstrating an increasing trend of AI integration into student study practices in Jordan (Al Mashagbeh, Alsharqawi, Tudevdagva, & Khasawneh, 2025, August). A recent survey conducted by the Digital Education Council, a global alliance of universities and industry representatives focused on educational innovation, found that the majority of students (86%) reported regular use of artificial intelligence in their studies (Kelly, 2024).

Table 1. Frequency of use of conversational AI tools

	Frequency	Percent	Valid Percent	Cumulative Percent
	2	9	16,7	16,7
	3	38	70,4	87,0
Valid	4	6	11,1	98,1
	5	1	1,9	100,0
	Total	54	100,0	100,0

Table 2 shows that 44.4% of students use conversational AI tools for less than 15 minutes, 48.1% for 15 to 30 minutes, and 7.4% for 30 to 60 minutes. These findings are consistent with previous research, which reported that 30% of participants use AI tools once a week or more, with 19% using them several times a week and 11% once or twice a week (Harris, Baldwin,

Davies, Gaines, Hill, Tharrington, & Sperr, 2025). Additionally, Web analytics data from Midhat Tilawat indicate an average ChatGPT session duration of approximately 12 minutes (12 minutes 9 seconds) (AllAboutAI, 2025).

Table 2. Duration of use of conversational AI tools

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	24	44,4	44,4
	2	26	48,1	92,6
	3	4	7,4	100,0
	Total	54	100,0	100,0

Figure 2 presents the primary purposes for which conversational AI tools are utilized: 30.2% for reading, 20.8% for writing, 7.5% for listening, 26.4% for speaking, and 15.1% for grammar. These findings suggest that students show greater interest in reading, writing, and speaking than in grammar and listening. This trend is supported by previous research, including Abduljawad (2024) and Elkaleh, Ali, Khurma, & El Sherif (2025), which found that the use of ChatGPT enhances students' writing abilities. Furthermore, in reading contexts, AI can support reading comprehension and learning by translating, clarifying, summarizing, and providing explanations to improve understanding (Tolstykh, O. M., & Oshchepkova, T.,2024).

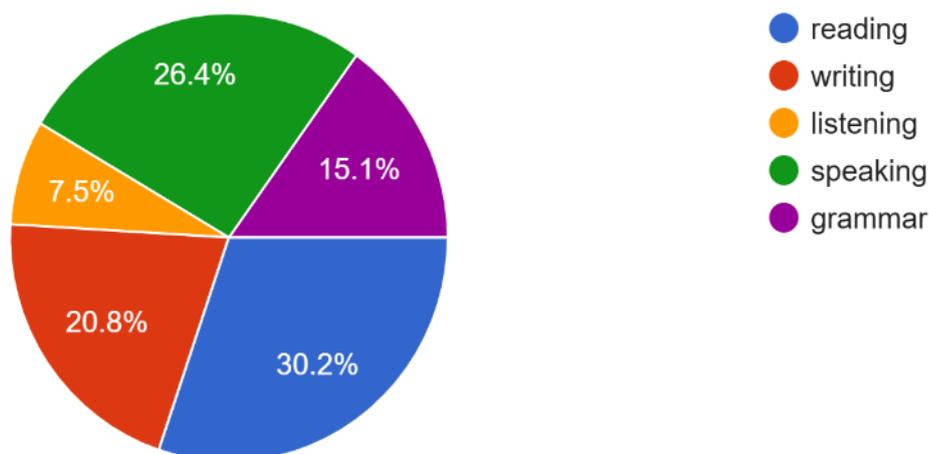


Figure 2. Purpose of using conversational AI tools

Table 3 presents students' use of conversational AI tools, with scores ranging from 4 to 9. The mean frequency of use was 5.61, with a standard deviation of 1.036. These results suggest that most responses were closely clustered around the mean, indicating relatively consistent usage

patterns within the sample. Artificial intelligence tools, such as ChatGPT, learning analytics, and automated assessments, have been adopted in the educational sector to transform instructional delivery and assessment models. AI provides instant feedback, adapts content in real time to individual learner progress, automates formative assessments, and generates personalized learning materials that address specific student strengths and weaknesses (Yadav, 2025).

Table 3. Utilization of conversational AI tools

	N	Minimum	Maximum	Mean	Std. Deviation
C.AI	54	4	9	5,61	1,036
Valid N (listwise)	54				

Additionally, AI presents opportunities to enhance traditional teaching and learning methodologies. In translation pedagogy, AI technologies have been applied to reduce assessment time and automate grading systems (Khasawneh and Shawaqfeh, 2024). The integration of AI into natural language processing (NLP) education has also led to improved instructional quality and increased learner engagement (Mishra, 2024).

Table 4 shows that students' scores ranged from 9 to 19, reflecting a moderate distribution of Renewing and Relearning levels. The mean score of 14.70 demonstrates that students, on average, performed above the scale's midpoint. The standard deviation ($SD = 2.107$) reveals relatively low variability, with most scores concentrated near the mean and few outliers. This distribution is consistent with previous research, which found that students employ meta-processes involving cognitive, behavioral, and affective learning strategies (Ben-Eliyahu, 2019). Accordingly, educators play a significant role in preparing children and youth to embrace new learning and relearning within self-regulated learning environments (SLEs) (Ben-Eliyahu, 2019).

Table 4. Renewing and relearning SLE component

	N	Range	Minimum	Maximum	Mean	Std. Deviation
RR	54	10	9	19	14,70	2,107
Valid N (listwise)	54					

Table 5 shows that students scored between 5 and 17 on Independent and Collaborative Learning. This range indicates that some students had lower engagement, while others achieved much higher scores, resulting in moderate overall variation. The mean score of 14.02 indicates that most students performed above the midpoint of the scale, reflecting generally positive learning behaviors. The standard deviation of 2.399, which is low relative to the range, indicates that most students scored near the mean. This limited variability indicates a cohort with similar, above-average engagement in both independent and collaborative learning.

Table 6 indicates that students' Active Learning scores ranged from 9 to 20, representing a moderately wide distribution of performance levels. The mean score of 14.81 demonstrates that, on average, students performed above the midpoint of the scale, reflecting generally positive engagement in active learning practices. The standard deviation of 3.263 indicates a substantial degree of variability among students; while many exhibited strong active learning behaviors, some displayed lower levels of engagement. This variability may be attributed to the feedforward loop, which is a process in which learners use self- or externally provided guidance to determine what to improve or adjust in subsequent similar tasks (García-Jiménez, Gallego-Noche, & Gómez-Ruíz, 2014). In this regard, the feedforward loop is considered as a critical skill that supports active learning.

Table 5. Independent and collaborative learning SLE component

	N	Range	Minimum	Maximum	Mean	Std. Deviation
ICL	54	12	5	17	14,02	2,399
Valid N (listwise)	54					

Table 6. Active learning SLE component

	N	Range	Minimum	Maximum	Mean	Std. Deviation
AL	54	11	9	20	14,81	3,263
Valid N (listwise)	54					

Table 7 presents descriptive statistics for the Transferability SLE component, which is defined as the ability to apply familiar strategies, processes, or skills across different domains or contexts (Tractenberg, FitzGerald, & Collmann, 2016). Transferability scores among students varied, ranging from 5 to 20. The mean score was 14.43, indicating that students generally

performed at a moderately high level on this construct. The standard deviation of 3.16 suggests that most students' scores clustered near the mean, although there was a moderate degree of individual variation. This distribution demonstrates diversity in students' levels of transferability.

Sustainable learning in education (SLE) serves as the dependent variable in this study, which aims to assess the impact of the use of conversational AI tools on sustainable learning practices. As shown in Table 8, Students' SLE scores ranged from 33 to 72 ($M = 57.76$, $SD = 9.21$), indicating moderately high self-efficacy overall, with substantial variability among participants.

Table 7. Transferability SLE component

	N	Minimum	Maximum	Mean	Std. Deviation
T	54	5	20	14,43	3,160
Valid N (listwise)	54				

Table 8. Sustainable learning in education (SLE)

	N	Minimum	Maximum	Mean	Std. Deviation
SLP	54	33	72	57,96	9,206
Valid N (listwise)	54				

The correlation between the use of conversational AI tools and sustainable learning in education was $r = 0.545$, which is statistically significant ($p < 0.05$) (Table 9). This result indicates a moderate positive association between these variables. Multiple studies have demonstrated that integrating artificial intelligence positively influences students' learning practices. The adoption of modern technologies, such as AI, enhances educational accessibility and effectiveness, thereby supporting the development of a generation prepared to address global challenges and promote sustainable development (Oleksenko, Nikitenko, Voronkova, Bakka, Popova, Bohomaz, & Bilohur, 2025).

Conversational AI tools facilitate personalized and adaptive learning experiences, improving overall educational outcomes (Zhang & Aslan, 2021; Su & Yang, 2023). Generative AI tools, including ChatGPT, have attracted significant attention in engineering education, providing benefits for both students and instructors (Qadir, 2023; Alasadi & Baiz, 2023). AI-powered systems, such as intelligent tutoring platforms and adaptive learning environments, deliver

dynamic, real-time feedback and personalized instruction by analyzing student performance data (Crompton and Burke, 2023; Kamalov, Santandreu Calonge, & Gurrib, 2023; Yang, Xiao, Wang, Zhang, Bian, Yin, ... & Wu, 2023). These technologies support mastery of complex topics, enable early identification of at-risk students, and facilitate targeted intervention strategies (Mackney & Shields, 2019; Chaudhry, Sarwary, El Refae, & Chabchoub, 2023; Embarak & Hawarna, 2024).

Table 9. Pearson correlation analysis of the key variables C.AI and SLE

		C.AI	SLP
C.AI	Pearson Correlation	1	,545**
	Sig. (2-tailed)		,000
	N	54	54
SLP	Pearson Correlation	,545**	1
	Sig. (2-tailed)	,000	
	N	54	54

** Correlation is significant at the 0.01 level (2-tailed)

Table 10 reveals a paradox in contemporary student learning. While students have access to tools that could promote intellectual complacency, they demonstrate advanced metacognitive awareness and deliberately use strategies to maintain equilibrium. Students actively shape their learning experiences by making intentional decisions about using conversational AI tools to support, rather than replace, their intellectual development.

The primary educational outcome evident in these essays is not efficient learning practices but ethical learning: students thinking critically about technology’s role in education and their intentional decisions about engagement. This finding is consistent with qualitative outcomes indicating that the use of conversational AI tools supports sustainable learning practices. Although artificial intelligence is a significant driver of sustainable development in education by improving quality, accessibility, and efficiency. However, its implementation necessitates careful consideration of the digital divide, ethical challenges, and social inequalities (Oleksenko, Nikitenko, Voronkova, Bakka, Popova, Bohomaz, & Bilohur, 2025). This suggests that the future of education in an AI era may depend less on institutional restrictions and more on cultivating the metacognitive awareness and intentionality these students already demonstrate.

Table 10. Thematic Summary of Students' Written Opinions

Theme	Frequency	Primary Benefit	Primary Risk	Student Response	Representative Quotes
Balance & Independence	85-90%	Maintains intellectual integrity	Over-dependence	Sequential work strategies	<ul style="list-style-type: none"> "I always try to write my own answers first, then use the AI to check" "AI should be a guide rather than relying on it for all the answers" "I write my ideas first, then use AI only to improve or check my work" "Use AI as a helper, not as a replacement for my brain" "Saves me a lot of time and helped me focus on understanding"
Efficiency	95%	Time-saving, speed	Rushing, shallow thinking	Intentional pace management	<ul style="list-style-type: none"> "Can explain hard ideas in just a few seconds" "Makes it possible to finish homework faster and understand difficult topics" "Summarizes long readings in seconds, which saves time and lets us focus on key points"
Over-Dependence	80%	Awareness of risks	Actual dependency	Self-regulation strategies	<ul style="list-style-type: none"> "Could also lead to over-reliance and addiction" "Might just ask the AI for a simple answer instead of thinking" "Makes students less confident in their own problem-solving skills" "Sometimes makes me lazy to think on my own" "Can make students depend too much on technology" "Weaken students' ability to express themselves clearly"
New Habits	75%	Faster feedback loops	Habit automaticity	Conscious strategy choice	<ul style="list-style-type: none"> More frequent feedback loops (immediate vs. delayed) Increased practice opportunity generation Enhanced writing through instant editing support More efficient information processing Greater autonomy in learning (not dependent on teacher availability)
Creativity	60%	Enhanced ideation	Creative replacement	Customization practices	<ul style="list-style-type: none"> "I use it to summarize long articles or for brainstorming and work them to make them my own" "Some use AI to get ready-made presentations"

5. Conclusion

This study found a strong relationship between the use of conversational AI tools and sustainable learning practices, as demonstrated by both quantitative and qualitative findings. These results highlight the significance of integrating AI into higher education and its positive impact on sustainable learning. Utilizing a mixed-methods design combining a survey and a writing task, the study emphasizes the importance of sustained AI use in education for promoting not only efficient but also ethical learning, which can be achieved through maintaining intellectual integrity. Put simply, critical reflection on technology's role in education informs intentional decisions regarding engagement with these AI tools.

In this regard, future research could focus on developing adaptive learning platforms that consider the four components of SLE. Further analysis of student progress and creation of personalized, sustainable learning instructions using conversational AI tools are needed. Additionally, organizing teacher training is recommended to implement innovative and sustainable teaching methods in the AI era. Ultimately, the integration of AI in education should be balanced with safeguards to protect privacy and prevent discrimination, promoting equality and equity for sustainable development.

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