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GENERATIVE AI IN SECONDARY EDUCATION: STUDENT IMMERSION ACROSS SOCIAL INNOVATION, MARKETING, AND PROGRAMMING

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ABSTRACT

The rapid integration of Generative AI (GenAI) into educational settings offers transformative potential for secondary education, yet empirical evidence regarding its practical application remains limited. This study investigates the efficacy of structured GenAI workshops conducted across four high schools in the Greater Jakarta area, involving 229 students engaged in sociopreneurship, digital marketing, and coding tracks. Utilizing a convergent mixed-methods design, the research combined quantitative surveys with sentiment analysis of open-ended reflections to evaluate student immersion and perception. The quantitative results demonstrated a strong positive reception, with the "Usefulness" of GenAI receiving the highest mean rating of 4.32 (SD = 0.77), and approximately 86% of participants affirming the tools' value for their academic studies. Sentiment analysis further confirmed high engagement, particularly in creative and technical problem-solving tasks, though qualitative feedback highlighted challenges regarding prompt formulation, data verification, and ethical concerns such as hallucinations. The study concludes that while GenAI serves as a powerful catalyst for creativity and learning efficiency, successful integration in secondary education necessitates a scaffolded pedagogical approach that prioritizes critical thinking, prompt engineering skills, and ethical reasoning to ensure responsible and effective usage.
Keywords: *Generative AI, secondary education, AI literacy, sentiment analysis, AI integration*

ABSTRAK

Integrasi cepat Generative AI (GenAI) ke dalam lingkungan pendidikan menawarkan potensi transformatif bagi pendidikan menengah, namun bukti empiris mengenai penerapan praktisnya masih terbatas. Studi ini menyelidiki efikasi lokakarya GenAI terstruktur yang diselenggarakan di empat sekolah menengah atas di wilayah Jabodetabek, yang melibatkan 229 siswa yang terlibat dalam program sosiopreneurship, pemasaran digital, dan pemrograman. Dengan menggunakan desain metode campuran konvergen, penelitian ini menggabungkan survei kuantitatif dengan analisis sentimen refleksi terbuka untuk mengevaluasi imersi dan persepsi siswa. Hasil kuantitatif menunjukkan penerimaan yang sangat positif, dengan "Kegunaan" GenAI menerima peringkat rata-rata tertinggi sebesar 4,32 (SD = 0,77), dan sekitar 86% peserta menegaskan nilai perangkat tersebut untuk studi akademis mereka. Analisis sentimen selanjutnya mengonfirmasi keterlibatan yang tinggi, terutama dalam tugas pemecahan masalah kreatif dan teknis, meskipun umpan balik kualitatif menyoroti tantangan terkait formulasi cepat, verifikasi data, dan masalah etika seperti halusinasi. Studi ini menyimpulkan bahwa meskipun GenAI berfungsi sebagai katalis yang kuat untuk kreativitas dan efisiensi pembelajaran, integrasi yang sukses dalam pendidikan menengah membutuhkan pendekatan pedagogis yang terstruktur yang memprioritaskan pemikiran kritis, keterampilan rekayasa yang cepat, dan penalaran etis untuk memastikan penggunaan yang bertanggung jawab dan efektif.
Kata kunci: *AI Generatif, pendidikan menengah, literasi AI, analisis sentimen, integrasi AI*

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INTRODUCTION

The integration of Generative AI (GenAI) into the landscape of secondary education represents a fundamental shift in how students interact with information, execute academic tasks, and develop essential future-ready skills. Advanced GenAI platforms, including prominent tools such as ChatGPT, Gemini, DeepSeek, Kling AI, Leonardo AI, Suno, and Runway ML, are currently empowering learners to generate diverse contents, ideate complex solutions, solve intricate problems, and significantly enhance creativity across a wide spectrum of subjects. Despite the rapidly growing access to these powerful tools among student populations, there remains a scarcity of comprehensive documentation regarding the tangible educational benefits of GenAI within higher education and K–12 environments. Current literature suggests that sustained engagement with GenAI is linked to substantial gains in students' innovation capacity and digital literacy (Wu & Zhang, 2025). Furthermore, specific applications, such as AI-assisted learning, have demonstrated the ability to help students generate code more efficiently in technical programming courses (Yang et al., 2025). These personalized AI systems have also shown considerable promise in boosting student motivation, providing tailored feedback, and promoting inquiry-based learning approaches (Noroozi et al., 2024; Zapata-Rivera et al., 2024). Ultimately, these tools enable a pedagogical shift from passive learning to active exploration, where students can co-construct knowledge with AI in dynamic subjects like entrepreneurship, design, and computing (Abdelghani et al., 2023; Chiu, 2024; Hayashi, 2024).

Nevertheless, alongside these transformative benefits, there is a growing body of concern regarding the potential drawbacks and unintended consequences of integrating GenAI into the classroom. A primary apprehension is that an over-reliance on GenAI tools may lead students to passively accept algorithmic outputs without necessary critical evaluation, a habit that could weaken their independent problem-solving skills and analytical reasoning abilities (Ferreira, 2024; Ortega-Ochoa et al., 2024). Furthermore, the unprecedented ease of generating sophisticated contents using AI tools has raised significant concerns regarding the maintenance of academic integrity, the validity of traditional assessments, and the authenticity or originality of student work (Fleckenstein et al., 2024; Haidar, 2024). Additionally, there is the technical issue that GenAI models often exhibit strong inherent biases due to the limitations and skew of their training data, which introduces a substantial risk of propagating misinformation or presenting unbalanced perspectives to impressionable learners (Kadaruddin, 2023; Noroozi et al., 2024). These multifaceted risks necessitate the development of comprehensive educational strategies that go far beyond merely teaching the technical operation of AI tools, emphasizing instead the critical importance of ethical reflection, deep critical thinking, and responsible engagement with artificial intelligence.

In response to these challenges, recent pedagogical frameworks have begun to emphasize the importance of mindful interaction with AI, the utilization of scaffolding techniques for deeper learning, and the robust development of AI literacy among students. However, a significant gap remains between these ideal frameworks and the reality on the ground, as many secondary educators report feeling underprepared to integrate GenAI tools effectively into their daily teaching practices. This lack of readiness indicates an urgent need for more structured support systems and targeted professional development programs to empower teachers (Cheah et al., 2025). Without adequate training and confidence, educators may struggle to guide students through the complexities of AI-assisted learning, potentially leaving the educational potential of these tools unrealized or misused. The disparity between the rapid advancement of AI technologies and the slower pace of teacher adaptation highlights

a critical area that requires immediate attention from educational stakeholders to ensure that the integration of technology enhances rather than hinders the pedagogical process.

Furthermore, a review of existing literature reveals a distinct gap in the target demographics of current research. Most empirical studies conducted to date have predominantly focused on university students in higher education settings, paying relatively little attention to the unique needs, developmental capacities, and specific learning conditions of secondary-level learners (Bolender et al., 2024; Durães et al., 2024; Kilde-Westberg et al., 2024). This oversight is critical because secondary students are at a formative stage in their cognitive development, where they are actively establishing their foundations in digital literacy, critical thinking, and ethical reasoning. Neglecting this demographic means that we lack sufficient evidence on how to best introduce these powerful technologies to younger learners in a way that maximizes their educational value while mitigating risks. Therefore, it is important to design early exposure mechanisms to GenAI that are specifically tailored to the maturity and curriculum requirements of high school students, ensuring that the technology serves a constructive purpose in their developmental trajectory.

This study aims to bridge these identified gaps by implementing a structured and innovative GenAI intervention across four Indonesian high schools located in the Greater Jakarta area. Through a series of carefully designed workshops focused on relevant contemporary topics such as *sociopreneurship*, digital marketing, and coding, students were given the opportunity to explore the practical, creative, and ethical dimensions of AI-assisted learning in a controlled environment. The research methodology utilized a mixed-methods approach, combining Likert-scale surveys with open-ended feedback narratives to comprehensively examine how students engaged with various GenAI tools. This approach allowed for a nuanced understanding of the benefits they gained, the challenges they experienced, and their evolving perspectives on responsible AI use. By focusing on the Indonesian context, this study also adds a necessary geographical diversity to the global discourse on AI in education, which is often dominated by perspectives from Western nations.

To guide this investigation, the study addresses three primary research questions that probe the student experience. First, it asks how secondary school students perceive the integration of GenAI across diverse academic tracks. Second, it investigates what specific benefits and challenges arise from students' direct engagement with GenAI tools. Third, it analyzes how student sentiment varies across different subject domains and reflection prompts. By answering these questions, this research contributes to generating vital empirical evidence that is currently lacking in the field. The findings are intended to guide educators, curriculum designers, and policymakers in shaping responsible, effective, and evidence-based AI integration strategies specifically for secondary education. Ultimately, this study seeks to provide a roadmap for navigating the complexities of the AI era in schools, ensuring that technology serves as a tool for empowerment and critical skill development for the next generation of learners.

METHODS

This study employed a convergent mixed-methods design, allowing for the simultaneous collection of quantitative and qualitative data to yield a comprehensive interpretation of a complex learning phenomenon. Participants in the study were 229 high school students, consisting of 27 10th-grade students and 202 11th-grade students, from four schools in the Greater Jakarta area. Participants were allocated to one of three thematic workshop tracks—sociopreneurship, digital marketing, or coding—based on their interests, with varying levels of technological proficiency from beginner to advanced. The entire research

process was conducted in accordance with strict institutional ethics protocols, with participation being voluntary and based on informed consent from both students and teachers. To ensure confidentiality and ethical research standards, all personal identifiers were removed and data were fully anonymized before analysis began, ensuring the protection of participants' rights and well-being throughout the study.

The intervention was implemented through ninety-minute AI Immersion Workshops, designed to balance conceptual understanding with practical applications using Generative AI (GenAI) tools. Sessions began with an introduction and demonstration of tools such as ChatGPT, Gemini, Leonardo AI, and GitHub Copilot, followed by hands-on practice where students produced tangible outputs such as a Business Model Canvas, visual marketing materials, or a Python interface using the tkinter library. Data collection instruments included a Likert-scale survey to measure engagement and usability of the tools, and an open-ended questionnaire to capture students' qualitative reflections. Throughout the workshops, instructors provided intensive guidance emphasizing the importance of fact-checking to mitigate the risk of AI hallucinations, ensuring that students used the technology as a cognitive partner and not a substitute for critical thinking in completing authentic tasks.

Data analysis was conducted using an integrated strategy within the Jupyter Notebook environment to ensure transparency and reproducibility of data processing. Quantitative data from the Likert scale was processed using descriptive statistics and histogram visualization to identify trends in participant perceptions. Meanwhile, qualitative data from open-ended responses were translated into English using the Helsinki-NLP/opus-mt-id-en neural translation model to maintain the integrity of meaning before further processing. Sentiment analysis was then run using the HuggingFace Transformers pipeline, which converts narrative responses into a numerical composite score to classify sentiment as positive, negative, or neutral based on standard VADER thresholds. Additionally, word clouds were generated to visualize keyword frequencies and dominant themes after stopword removal, providing in-depth insights that complement the statistical findings regarding the impact of GenAI in education.

RESULTS AND DISCUSSION

Quantitative and qualitative data were triangulated to evaluate student engagement, usability perceptions, and reflective attitudes toward GenAI integration.

Quantitative Analysis

The quantitative analysis draws from structured survey data collected at the conclusion of each workshop session across four participating schools. In total, 229 students completed the post-workshop questionnaire, providing both Likert-scale ratings and open-ended reflections. The Likert-scale statements were clustered into four categories, with the corresponding survey items shown in quotes, as follows:

1) Interest: “GenAI integration was interesting and engaging”
2) Usefulness: “GenAI useful in my studies”
3) Applicability: “Similar activities engaging in classes”
4) Ease of Use: “GenAI tools were easy to use”

Table 1 summarizes participant distribution across sessions. Each school hosted between three and four sessions, with participant counts ranging from 12 to 24 students per session. This distribution reflects logistical factors such as class grouping and scheduling, while also ensuring a diverse and representative sample across academic tracks. The high response rate and balanced distribution across sessions support the reliability of the quantitative findings presented in the following sections.

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Table 1. Participant Count per Session

school	workshop session	participant count
School A	Session 1	20
	Session 2	14
	Session 3	15
School B	Session 1	14
	Session 2	17
	Session 3	20
School C	Session 1	13
	Session 2	24
	Session 3	20
School D	Session 1	19
	Session 2	17
	Session 3	24
	Session 4	12
Total		229

Table 2 presents the descriptive statistics for four survey items assessing participants' perceptions of the GenAI-integrated session. The highest average rating was for Usefulness (Mean = 4.32, SD = 0.77), indicating that participants found the session helpful for understanding how GenAI can support their studies. Interest and Ease of Use both had a mean of 4.17 (SD = 0.76), suggesting that participants found the session engaging and the tools user-friendly. Applicability—how engaging similar activities might be in regular college classes—had the lowest mean at 4.02 (SD = 0.81), though still relatively high.

Table 2. Descriptive Statistics

statistic	interest	usefulness	applicability	ease of use
Mean	4.17	4.32	4.02	4.17
Standard Deviation	0.76	0.77	0.81	0.76
Min	1	1	1	2
Median	4	4	4	4
Max	5	5	5	5

Responses to the four Likert-scale statements were consistently positive, with median ratings of 4 and interquartile ranges between 4 and 5 across all items. Only a few outliers (ratings of 1–2) appeared, indicating that while most participants viewed the GenAI session favorably, a small number were less satisfied. The overall uniformity of responses suggests that participants shared a broadly similar, positive experience with the session.

Figure 1 displays the Spearman correlation coefficients among four Likert-scale items: Interest, Usefulness, Applicability, and Ease of Use. All correlations are positive and moderate in strength, ranging from 0.51 to 0.63, indicating a consistent pattern of related perceptions among participants. The strongest correlation was observed between Interest and Usefulness ($\rho = 0.63$), suggesting that participants who found the GenAI session interesting also tended to perceive it as useful. The weakest, though still moderate, correlation was between Usefulness and Applicability ($\rho = 0.51$), indicating a slightly lower association between seeing value in GenAI and believing similar activities would be engaging in academic settings. Overall, the moderate correlations suggest that while the constructs are related, they capture distinct aspects of the participants' experiences.

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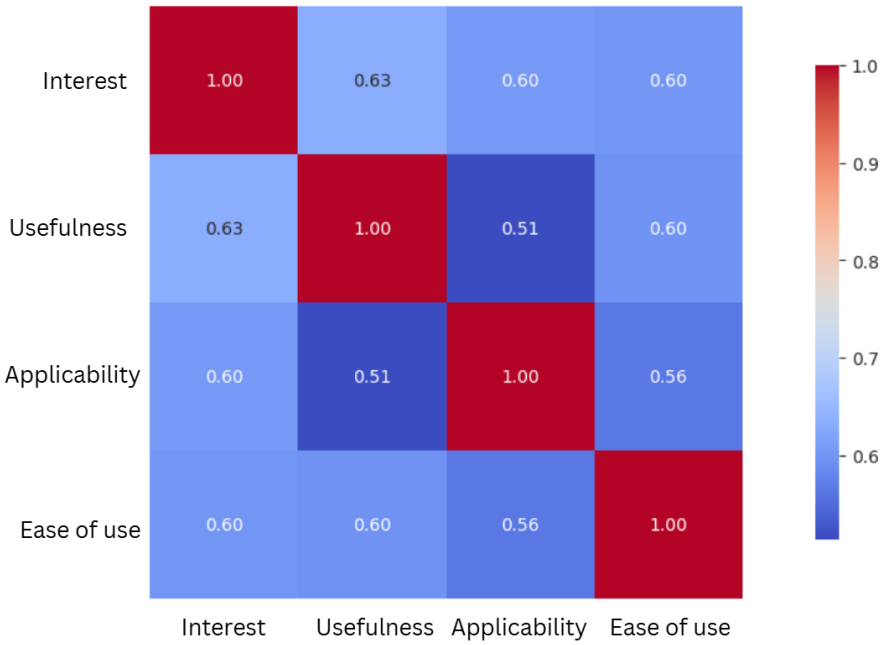

Figure 1. Spearman Correlations between Likert Items

Student responses indicate positive perceptions of the GenAI-integrated workshops. Most participants found the activities engaging and relevant, with Likert-scale responses strongly skewed toward the upper end of the scale. As shown in Figure 12, nearly 83% of students selected ratings 4 or 5 when asked if the GenAI activities were interesting and engaging.

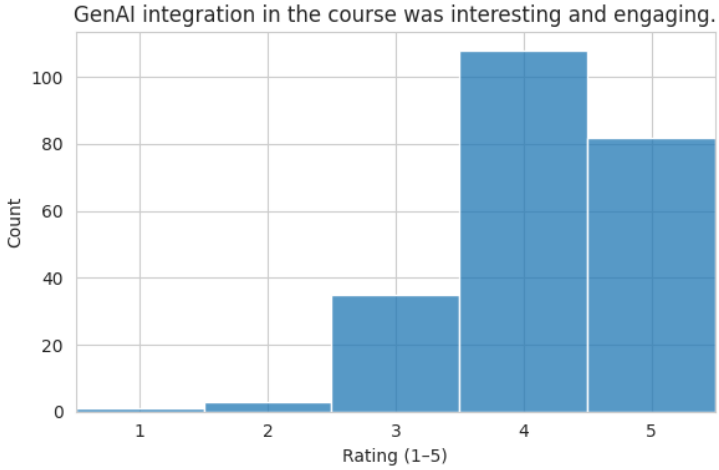

Figure 2. Student ratings for the "GenAI integration in the course was interesting and engaging" statement

Similarly, for the statement, "The session helped me see how GenAI can be useful in my studies," over 86% chose 4 or 5 (Figure 3), indicating that students not only enjoyed the sessions but saw direct academic value in the tools.

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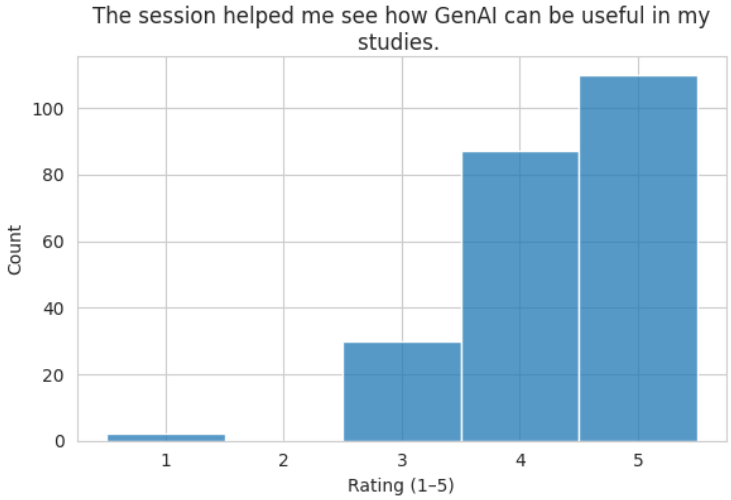

Figure 3. Student ratings for the "The session helped me see how GenAI can be useful in my studies" statement

Students also expressed strong support for incorporating similar GenAI activities into future college learning. Approximately 75% of responses to this item (Figure 4) clustered at 4 or 5, suggesting that the perceived value of GenAI tools extends beyond the novelty of the workshop. Importantly, ratings of 1 or 2 were almost nonexistent across all items, reinforcing the consistency of positive experiences.

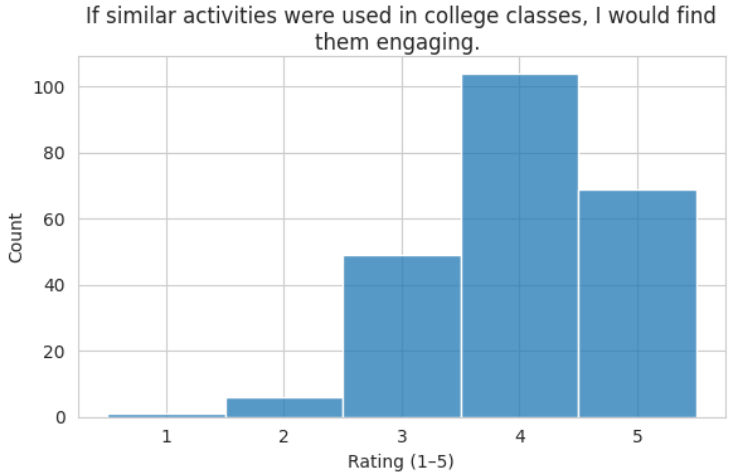

Figure 4. Student ratings for the "If similar activities were used in college classes, I would find them engaging" statement

Regarding usability, Figure 5 shows that students generally found the GenAI tools easy to use. Around 84% of students gave usability ratings of 4 or 5, suggesting that tool accessibility was high and that the AI interfaces did not pose significant barriers to participation.

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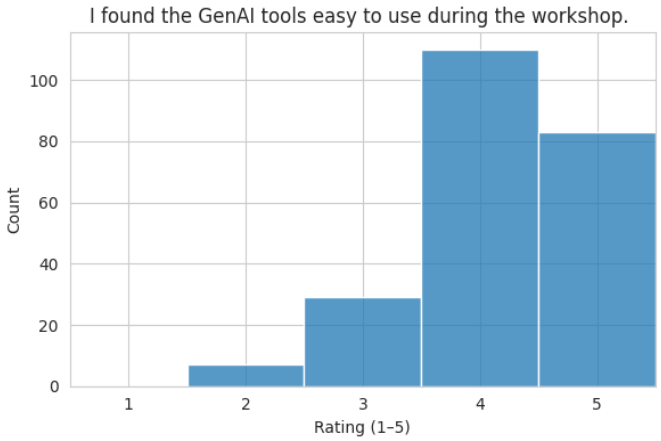

Figure 5. Student ratings for the "I found the GenAI tools easy to use during the workshop" statement

Qualitative Analysis

In addition to rating-based responses, an analysis of sentiment scores derived from open-ended feedback was conducted (Figure 16). The boxplot shows the sentiment distribution across five questions (Q1 to Q5), with sentiment scores ranging from -1 (strongly negative) to +1 (strongly positive). The five questions were:

1) Q1: What was the most interesting part of the workshop for you?
2) Q2: What challenges did you face, if any?
3) Q3: What could be improved in the GenAI integration in the courses?
4) Q4: Do you think GenAI tools like the ones you used today would be beneficial if included in college learning? Why or why not?
5) Q5: Free space: feel free to write anything related to today's session!

Sentiment analysis across five reflection questions revealed strong positive effects, particularly in responses related to potential academic benefits (Q4) and overall impressions (Q5). These two questions had median sentiment scores above 0.75, with narrow interquartile ranges suggesting consistent positivity across respondents (Figure 6).

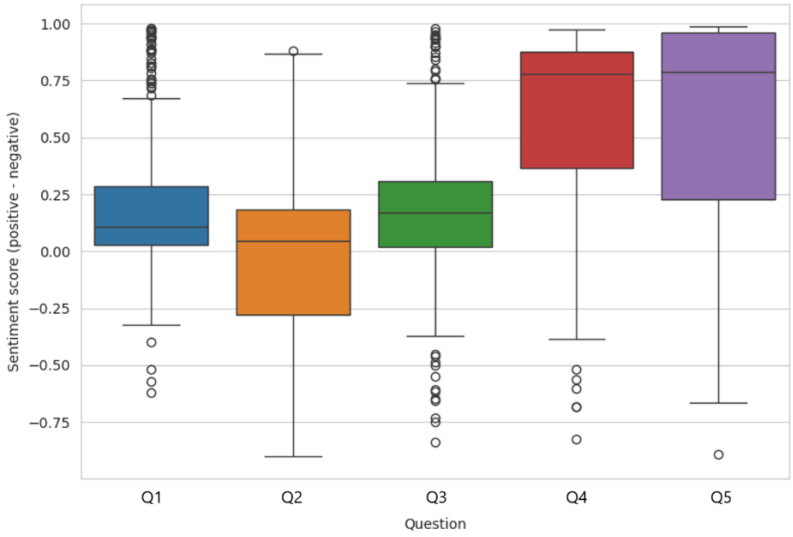

Figure 6. Sentiment analysis for Question 1 to Question 5

To illustrate how sentiment varied across student reflections, representative responses were selected for each of the five open-ended questions, presented in Table 4 below. These

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examples highlight the diversity of emotional tone in student feedback, ranging from enthusiastic endorsements of GenAI's educational value to more cautious or critical remarks. For each question, one positive, one neutral, and one negative response is presented, along with its translated text and sentiment score. This qualitative snapshot complements the sentiment distribution shown in Figure 6 and provides concrete insight into how students interpreted and experienced GenAI integration during the workshop.

Table 3. Samples of Open-Ended Responses by Sentiment Category

question	sentiment	response (translated)	score
Q1: Most interesting part	Positive	The instructor explained it so cheerfully that we who listened were greatly assisted by the workshop he brought along.	0.97
	Neutral	I (now) know GenAI can answer a question as detailed and specific as we want	0.01
	Negative	It turns out that AI and Gen AI are different, and it turns out that AI still has flaws.	-0.57
Q2: Challenges faced	Positive	Nothing	0.25
	Neutral	I face challenge to know how to use GenAI correctly and generate prompt properly	-0.01
	Negative	Yes, i faces challenges such as how to write prompt correctly or how to check any ai mistakes	-0.51
Q3: Suggestions for improvement	Positive	Introducing more relevant use of AI in solving everyday's problems	0.44
	Neutral	more accurate data maybe?	0.04
	Negative	Make the videos more fluent, and tone it down with the shading. It looks like it's basically made out of bismuths.	-0.75
Q4: Is GenAI beneficial?	Positive	Useful because for sure in the future, AI and technology will be used more in their daily lives.	0.95
	Neutral	-	-
	Negative	Maybe, I mostly focus on animations... It's good at giving inspiration but not good at giving an example.	-0.52
Q5: Free comments	Positive	Today was so exciting, I found out that for example, AI was not 100% trustworthy	0.45
	Neutral	-	-
	Negative	-	-

Qualitative (table 3) analysis of participant responses revealed a deep appreciation for the practical aspects of the workshop, while also highlighting technical areas requiring further support. In the first question, hands-on activities such as coding and poster creation were considered the most engaging segment, providing concrete evidence of how artificial intelligence can streamline daily work and support the exploration of global issues like the SDGs. However, significant technical challenges persisted, as reflected in responses to the second and third questions. The primary obstacles students faced revolved around the difficulty of designing precise prompts and verifying the accuracy of AI output. This indicates that,

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despite high participant enthusiasm, there is a pressing need for structured scaffolding to help students overcome these technical challenges. Critical feedback from students requesting clarity of instructions and more accurate data demonstrates that they are not simply passive users, but rather critical observers seeking a deeper understanding of the limitations and capabilities of the technology they are learning about.

An evaluation of the workshop's overall impact revealed a predominantly positive sentiment, both in terms of technology acceptance and affective learning experiences. Responses to the fourth and fifth questions consistently showed an affirmative attitude, with the majority of students recognizing GenAI's utility as a vital tool that accelerates academic work and learning processes. Aggregate word frequency analysis, as validated by Table 5, confirms this pattern by placing the words "AI," "yes," and "help" as the most frequently occurring terms (reaching 250 occurrences for the word "AI"). This dominance of words reflects a shift in students' views, who now see AI as a strategic partner in education. The combined word cloud visualization filled with positive-sounding terms such as "happy," "good," and "learning" provides strong qualitative confirmation that the workshop's objectives have been achieved, not only in transferring technical knowledge, but also in building students' positive perceptions and openness to future technology integration.

Table 4. Top 10 Words in Translated Open-Ended Student Responsese

rank	word	frequency
1	ai	250
2	yes	142
3	go	105
4	let	102
5	genai	94
6	use	94
7	help	84
8	us	63
9	make	60
10	learning	57

Sentiment analysis across all five open-ended questions (Q1–Q5) revealed that students responded positively to the GenAI-integrated workshops while providing constructive feedback for improvement (Table 4). Responses to Q1 emphasized enjoyment of hands-on and creative activities, particularly coding, poster generation, and problem-solving with GenAI tools, reflecting strong engagement and curiosity. Q2 highlighted technical challenges such as prompt formulation and data validation, pointing to the need for clearer guidance. For Q3, students offered practical suggestions to enhance relevance and accuracy, such as providing more real-world examples and structured instruction. Q4 showed overwhelmingly positive sentiment, with most participants acknowledging the academic value and future potential of GenAI tools, while Q5 captured general appreciation and enthusiasm for the learning experience. Together, these responses illustrate that students found the sessions engaging, beneficial, and ethically thought-provoking, while also recognizing opportunities for refinement in future implementations.

Discussion

Here is the translation in a formal academic register, suitable for a discussion or conclusion section of a research paper:

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The results of this exploratory study provide strong empirical evidence regarding the promise and complexity arising from the integration of Generative Artificial Intelligence (GenAI) in secondary education environments. A prominent finding is the exceptionally high level of student engagement during the workshops, measured through both self-assessment and qualitative feedback. The hands-on and applied nature of the designed activities—ranging from coding and marketing to business design—proved to be major driving factors for student motivation in learning. This confirms that technology-supported active learning approaches can create a dynamic and non-monotonous learning atmosphere. These findings align with previous theoretical frameworks suggesting that AI-supported learning can foster greater cognitive engagement and facilitate deep interdisciplinary exploration (Chiu, 2024; Ferreira, 2024). Furthermore, student enthusiasm did not stop merely at the use of the tools but demonstrated a sustained interest in integrating similar tools in future academic settings, signaling broad instructional relevance.

Beyond engagement, this study clearly demonstrates that students perceive GenAI as a highly valuable academic aid in their learning process. Participants described this technology as a helpful tool for brainstorming, creative content creation, and accelerating the completion of technical tasks that usually consume significant time. This positive perception confirms prior research highlighting the crucial role of AI in enhancing creativity, personalized learning, and overall academic performance (Chiu, 2024; Villena Zapata et al., 2024). GenAI's ability to provide initial ideas and basic structures enables students to overcome writer’s block and focus on higher-order aspects of creation. This indicates that when integrated correctly, technology does not replace the student's role, but acts as a cognitive partner extending their intellectual capacity in solving complex academic problems.

The implications of applying this technology are also evident in the context of career preparation and future workforce relevance. The interdisciplinary application of GenAI in this workshop, covering entrepreneurship, coding, and design, greatly helped students connect technology with various potential career paths. Student enthusiasm for using GenAI at the university level suggests that early exposure to this technology can significantly contribute to their long-term academic readiness. This aligns with future workforce demands increasingly requiring advanced digital literacy and adaptability to intelligent tools (Hayashi, 2024; Chen, 2023). Thus, introducing GenAI in secondary schools is not just about teaching software usage, but about forming an adaptive mindset enabling students to navigate a professional landscape that is constantly changing and increasingly dominated by intelligent automation.

Although overall satisfaction was high, students faced specific challenges requiring serious attention from educators and curriculum developers. Difficulties in prompt formulation, interpreting AI-generated outputs, and evaluating content validity were issues most frequently cited by students. These challenges echo broader concerns in the literature regarding the risk of shallow learning occurring when students rely too heavily on AI without critical engagement (Abdelghani et al., 2023; Ortega-Ochoa et al., 2024). This phenomenon shows that access to advanced technology alone does not guarantee effective learning without strong conceptual understanding. Without the ability to critique machine-generated results, students risk accepting biased information or AI hallucinations as factual truth, which can ultimately degrade the quality of their material understanding.

Findings regarding these technical and cognitive challenges underscore the urgent need for adequate instructional scaffolding in AI-based learning. Student difficulties are largely rooted in their unfamiliarity with the operational logic of GenAI tools, but this also highlights the need for explicit education on prompt engineering, content validation, and ethical reasoning. Educators can no longer assume that students, as digital natives, will intuitively adapt to

emerging technologies without structured guidance. Therefore, these findings support calls to explicitly embed AI literacy within the school curriculum (Abdelghani et al., 2023; Ortega-Ochoa et al., 2024). This literacy education must go beyond operational technical aspects to include understanding how large language models work, potential biases, and data usage ethics so students can become wise and responsible users.

Responding to existing challenges, students provided thoughtful suggestions to improve the learning experience using GenAI, centering on the need for clearer guidance and collaborative activities. Many suggestions implicitly called for greater emphasis on critical AI literacy—the ability to ask good questions, validate results, and challenge AI outputs when necessary. These student recommendations align well with new pedagogical frameworks advocating for mindful and reflective AI engagement (Ferreira, 2024; Chen, 2023). Moving forward, educators are advised to incorporate structured activities developing these metacognitive and ethical competencies alongside tool proficiency. Collaborative or peer learning is also suggested as an effective method, where students can share prompting strategies and discuss obtained results, creating a critical and supportive learning community (Dila et al., 2025; Horvat et al., 2021; Lawitta & Najdah, 2025).

Finally, the interpretation of these results must consider several existing methodological limitations. First, the intervention was conducted in a specific geographical and institutional context, which may limit the generalizability of findings to broader populations. Second, the novelty of GenAI tools may have temporarily boosted student enthusiasm, a factor known as the novelty effect, which might diminish over time. Third, sentiment analysis in this study relied on machine-translated data and English-based Natural Language Processing (NLP) models, which may have reduced cultural nuances in interpreting student feedback. Additionally, reliance on self-reported data may not fully capture actual learning outcomes or tangible behavioral changes. Future research needs to address these limitations with longitudinal designs and more objective evaluation methods to understand the long-term impact of AI integration in education.

CONCLUSION

This research provides compelling preliminary evidence that the integration of well-designed Generative AI (GenAI) tools into secondary education can significantly increase student engagement, foster creativity, and facilitate in-depth ethical reflection. Through practical applications in entrepreneurship, coding, and digital marketing activities, students not only gain valuable technical experience but also gain critical insights into the limitations and risks of these technologies. The study findings specifically highlight that students responded very positively to GenAI-supported activities, finding them to be relevant and easy-to-use learning tools, particularly for brainstorming, idea development, and technical problem-solving. While students' enthusiasm was high, their identification of real-world challenges such as effective prompt design and data reliability underscores the urgency of balancing technical exposure with explicit instruction in AI literacy. This underscores that technology adoption must always be accompanied by critical understanding so that students become not merely passive users but rather discerning and responsible evaluators of technology in their learning process.

Based on these evaluative findings, strategic steps for future implementation should focus on refining the workshop model to include more structured guidance on prompt engineering, content evaluation, and a stronger emphasis on ethical scenarios and responsible use. The model's adaptability has proven to be significant, allowing it to be extended to other educational contexts, including universities and teacher professional development programs, to

ensure the readiness of the entire educational ecosystem. Further research is strongly recommended to explore the long-term impact of early exposure to GenAI on students' digital competencies and to analyze the readiness of educators and institutional policies to adopt this new pedagogy. Given GenAI's increasingly dominant role in shaping the modern educational and workplace landscape, preparing students to engage with this technology critically and ethically is no longer an option but an absolute necessity. This study contributes significantly by offering a practical and empirical framework for reflectively integrating GenAI, ensuring students are prepared for future challenges.

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