Evaluating the Impact of Generative AI Tools on Learning Outcomes, Motivation, and Cooperation in Programming-Related Courses

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Abstract: This study examines the role of generative AI tools, such as ChatGPT, Copilot, and Gemini, in enhancing learning effectiveness, motivation, and cooperation in programming-related courses. Using a pre- and post-course survey design, we collected and analyzed data from students who integrated these AI tools into their learning activities. The findings reveal that generative AI tools improve learning outcomes, foster motivation, and promote cooperation in team-based tasks. Students reported increased confidence in autonomous learning and a willingness to adopt AI tools for future cooperative projects. By highlighting the educational potential of generative AI, this study provides insights into their effective integration into curricula, paving the way for more innovative teaching and learning strategies.

Keywords: Cooperative learning, generative AI, learning effectiveness, learning motivation

1. Introduction

1.1 Background

The rapid integration of artificial intelligence (AI) tools into educational environments has transformed the way students and educators approach learning (Adeshola & Adepoju, 2024; Zhai et al., 2021; Zhang & Aslan, 2021). Especially, generative AI tools such as ChatGPT, Copilot, DeepSeek, and Gemini refer to AI tools that create human-like content such as text, images, music, and videos by learning patterns from existing data (Bengesi et al., 2024; Dhamanim, 2024; Feuerriegel et al., 2024; McIntosh et al., 2022). These tools offer a range of functionalities, including personalized guidance, instant feedback, and cooperative support, making them valuable resources for modern education. With their ability to provide real-time assistance and adapt to individual learning needs, AI tools hold the potential to enhance learning outcomes, boost motivation, and support cooperative learning activities.

Despite these promising benefits, the effectiveness and reception of such tools in real-world academic settings remain underexplored. Understanding how students perceive and utilize AI tools before and after engaging with them in a structured course is critical to optimizing their use and identifying potential challenges. This research seeks to fill this gap by evaluating the role of AI tools in shaping student experiences and outcomes in higher education.

1.2 Research Objectives

In this research we focus on the following four objectives:

1. Evaluate Learning Effectiveness: To assess how generative AI tools impact students' perceived learning effectiveness during a course.
2. Boost Learning Motivation: To explore the influence of AI tools on students' motivation to engage with course materials and activities.
3. Support Cooperative Learning: To investigate the role of AI tools in fostering autonomous and team-based learning experiences.
4. Analyze Perception Shifts: To examine changes in students' perceptions of AI tools from the beginning to the end of a course.

1.3 Research Questions

We aim at answering the following four research questions:

1. Learning Effectiveness: Do AI tools improve students' perceived learning effectiveness?
2. Motivation: How do AI tools influence students' motivation to learn?
3. Cooperative Learning: To what extent do students perceive AI tools as valuable partners in cooperative learning activities?
4. Perception Changes: How do students' attitudes toward and perceptions of AI tools evolve throughout the course?

2. Literature Review

2.1 Overview of AI Applications in Education

The integration of artificial intelligence (AI) into education has grown exponentially, with tools like ChatGPT, Copilot, and Gemini leading the way (Beck et al., 1996; Fitria, 2021; Zhai et al., 2021; Zhang & Aslan, 2021). AI applications in education encompass a wide range of functionalities as shown in Table 1.

Table 1. AI Application in Education

AI Application	Description
Personalized Learning	AI systems tailor content to meet individual student needs, identify areas for improvement, and offer customized recommendations.
Assessment and Feedback	Automated grading and AI-driven feedback provide immediate, accurate evaluations of student work, streamlining assessment processes (Owan et al., 2023)
Tutoring Systems	Virtual tutors like ChatGPT offer 24/7 assistance, helping students grasp complex topics and concepts.
Language and Communication	AI tools improve language learning and enhance writing and communication skills through real-time corrections and suggestions.
Collaborative Tools	AI supports team projects by acting as a mediator, collaborator, or brainstorming partner, fostering cooperation and innovation.

The adoption of these tools is driven by their potential to make learning more efficient, engaging, and inclusive. However, challenges like ethical concerns, reliability, and equitable access must be addressed to maximize their impact.

2.2 Generative AI in Education

Generative AI creates human-like content by learning from existing data. In the context of education, generative AI can assist in developing personalized learning experiences, generating educational content, and providing feedback (Qadir, 2023; Rahman, 2023; Su & Yang, 2023). By using advanced algorithms, generative AI can offer tailored support to students and educators, automating many aspects of the teaching and learning process. These systems typically employ unsupervised or self-supervised learning to recognize data structures and generate useful outputs, making them highly valuable in educational settings.

Generative AI in education often uses several key approaches. Generative Adversarial Networks (GANs) can be used to create realistic simulations or educational images and videos, enhancing visual learning experiences (Aggarwal et al., 2021). Variational Autoencoders (VAEs) are useful for generating variations of learning materials, such as interactive exercises or alternative problem sets, to aid in student practice (Doersch, 2016). Transformer models like GPT excel in generating natural language content, making them ideal for tutoring systems, chatbots, and personalized feedback. Diffusion models, which can generate high-quality images, may be used in creative courses like design, offering students unique tools for generating visual ideas based on prompts or descriptions.

Generative AI has numerous applications in education. It can generate text for assignments, quizzes, and interactive learning activities, providing instant feedback to students. AI tools like chatbots can assist in answering student queries, offering explanations, and even simulating tutoring sessions. For creative fields, AI can generate images, designs, and music to inspire students in art and design courses. Additionally, generative AI can help in language learning by creating personalized exercises or writing prompts. The benefits are clear: AI enhances creativity, provides individualized learning experiences, reduces teacher workload, and democratizes access to high-quality educational resources for both students and instructors.

Generative AI in education holds great potential, but challenges remain. Key concerns include bias in AI-generated content, the risk of misuse (e.g., misinformation), and intellectual property issues related to AI-created assignments. Additionally, the computational resources needed for training these models can limit accessibility. As ethical AI practices improve and computational efficiency advances, generative AI is poised to revolutionize education, fostering personalized and adaptive learning experiences while enhancing teaching and learning outcomes, as anticipated in this research.

2.3 Cooperative and Autonomous Learning Theories

Cooperative learning is an educational approach where students work together in small groups to achieve shared learning goals (Felder & Brent, 2007; Roger & Johnson, 1994; Slavin, 1980). Key principles include:

- Positive Interdependence: Group members rely on each other to complete tasks.
- Individual Accountability: Each student is responsible for contributing to the group's success.
- Face-to-Face Interaction: Direct interaction fosters collaboration and knowledge exchange.

AI tools support cooperative learning by:

- Acting as a cooperative partner.
- Offering suggestions to guide group discussions and tasks.
- Mediating disagreements or facilitating consensus in team-based activities.

Autonomous Learning: Autonomous learning emphasizes the student's ability to take control of their own learning process (Nunan, 1996). Core elements include:

- Self-Directed Goals: Students independently set and work toward learning objectives.
- Self-Regulation: Learners monitor their progress and adjust strategies to achieve their goals.
- Intrinsic Motivation: Autonomy fosters deeper engagement with learning tasks.

AI tools, such as ChatGPT and Copilot, enhance autonomous learning by providing personalized resources, answering individual queries, and offering actionable feedback without constant instructor intervention (Wang & Li, 2024)

2.4 Existing Research on AI Tools and Their Educational Impact

Numerous studies have explored the impact of AI tools on education (Lo, 2023), particularly their role in improving learning outcomes, motivation, and cooperation. Key findings are shown in Table 2.

Table 2. Summary of the Impact of AI Tools on Education

Aspect	Details
Learning Effectiveness	Students using AI tools like ChatGPT, Copilot, and Gemini perform better in tasks requiring problem-solving, critical thinking, and comprehension (Imran & Almusharraf, 2024). These tools offer instant feedback and resources, reducing frustration and enhancing conceptual understanding.
Motivation	AI tools increase student engagement and motivation by making learning more interactive and accessible. Gamified features and conversational interfaces encourage active participation.
Teamwork and Collaboration	AI tools foster teamwork by assisting in brainstorming, organizing ideas, and mediating discussions. Tools like Copilot are particularly effective in coding projects, acting as reliable collaborators.
Student Perceptions	Research reveals mixed responses: many students value the convenience and support of AI tools, while others raise concerns about over-reliance and the potential loss of critical thinking skills.

Despite these promising results, gaps remain in understanding how students' perceptions evolve over time and the long-term impact of AI tools on educational outcomes. This study aims to bridge these gaps by focusing on generative AI tools in the context of higher education.

3. Methodology

The study involved programming students and used pre- and post-course surveys to assess the impact of AI tools, primarily ChatGPT, on learning, motivation, and cooperation. The survey included 10 Likert-scale questions on AI-assisted learning and its effectiveness. AI tools were integrated into activities like answering questions, study guidance, and group projects. Data were analyzed using statistical methods, including paired t-tests, mean values to assess changes in student perceptions, while open-ended feedback was analyzed thematically to capture qualitative insights.

3.1 Participants

This study involves undergraduate students enrolled in the following two courses as shown in Table 3. Most students use ChatGPT as an AI tool. Students from different academic disciplines are invited to participate, providing varied perspectives on generative AI's role in education. Participation is voluntary, with consent obtained to ensure ethical compliance. The sample size is determined to allow for meaningful statistical analysis.

Table 3. Overview of Course and Survey Participant Details

Course	C++ Programming	Python Smart Commerce Applications
Course Type	Required	Required
Participants	86 Students (Mainly Sophomore)	20 students (Mainly Junior)
Department	Computer Science and Information Engineering	Applied Foreign Languages and Smart Commerce
University	Chung Hua University	
Location	Hsinchu City, Taiwan	
Semester	Fall 2024	
AI Tools Used	Primarily ChatGPT (based on coursework statistics)	

3.2 Integrating Generative AI Tools in Course Plan and Assignments

Integrating generative AI tools, such as ChatGPT, into programming-related assignments fosters innovation, critical thinking, and practical problem-solving skills. Table 4 presents a simplified 18-week course plan, outlining how AI tools can be effectively integrated into programming courses to enhance learning, problem-solving, and collaboration. Note that a semester has 18 weeks at Chung Hua University.

Table 4. Integrating Generative AI Tools in Course Plan

Duration	**Topic**	**Activity**	**AI Tool Integration**
Week 1	Introduction to AI in Programming	Overview of generative AI tools, ethical use, and limitations.	Provide a guided tutorial on using AI tools for queries and programming assistance.
Week 2 - Week 14	Code generation, debugging,	Homework: Develop programs using AI tools for assistance and guidance.	Assign tasks that encourage students to use AI tools for debugging, algorithm design, or testing.
Week 3	Term Project Proposal	Term project ideation: Brainstorm project ideas and write a proposal.	Use AI tools for brainstorming and drafting the proposal, focusing on feasibility and innovation.
Week 3 - Week 16	Team Cooperation	Group activity: Work cooperatively with AI tools to solve a complex programming challenge.	Leverage AI tools for brainstorming, code generation, and task delegation within teams.
Week 4 - Week 16	Project Development	Term project: Develop a functional application with complete documentation.	Use AI tools for coding, debugging, and generating documentation like user manuals and reports.
Week 10 – Week 17	Testing and Validation	Homework: Write unit tests for given programs and validate functionality.	Utilize AI tools to generate test cases and analyze program behavior.
Week 18	Reflection and Presentation	Present term projects and submit a reflection on AI tool usage.	Reflect on how AI tools enhanced learning, motivation, and cooperation.

This paragraph demonstrates how AI tools are integrated into assignments. Tables 5 and 6 present examples from assignments in C++ Programming and Python Smart Commerce Applications, respectively.

Table 5. Part of the Term Project Guideline of C++ Programming

C++ Programming Term Project - Fall 2024
Term Project Guideline
Goal: The project aims to give students practical experience in implementing AI applications with the help of tools like ChatGPT, Copilot, and Gemini.
Possible topics include but not limited to: 1. Image Classification with OpenCV 2. Handwritten Digit Recognition (MNIST) 3. Face Detection and Recognition 4. Natural Language Processing (NLP) 5. Speech Recognition 6. Pathfinding and Maze Solving Using AI Algorithms 7. Self-Driving Car Simulation 8. AI-Based Chess Engine 9. Recommendation System 10. Real-Time Object Detection 11. Genetic Algorithms for Optimization Problems 12. AI-Powered Game Bot 13. Pose Detection and Gesture Recognition

Table 6. Part of Homework 5 of Python Smart Commerce Applications

Smart Commerce with Python - Homework 5
Objective: This assignment aims to help students understand the foundational concepts of deep learning by building and training simple neural networks using TensorFlow/Keras or PyTorch.
Instructions: 1. Install TensorFlow and Keras or PyTorch to set up your development environment. 2. Complete each task below using Python, ensuring that your code includes comments explaining the functionality of each section. 3. For each question, run the model and record the output or results. Analyze the performance based on accuracy and loss metrics. 4. For every question, specify: • Which AI tool(s) you used. • The approximate percentage of work contributed by the AI tool. • A brief explanation of how the AI tools assisted in completing your assignment.

3.3 Survey Design

A structured survey is used to assess students' perceptions of impact of generative AI tools on their learning experience as shown in Table 7. Each statement is rated on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) to measure agreement levels across the following areas.

Table 7. Survey Questions

Category	Survey Questions
Learning Effectiveness	Q1: The generative AI tool enhances my learning effectiveness.
	Q2: The generative AI tool provides accurate answers to learning questions.
	Q3: The generative AI tool offers valuable suggestions and guidance.
Motivation and Autonomous Learning	Q4: The generative AI tool boosts my motivation to learn.
	Q5: The generative AI tool personalizes its responses to my individual needs.
	Q6: The generative AI tool contributes to a better autonomous learning experience.
Cooperative Learning and Future Usage	Q7: I am willing to use the generative AI tool for lesson preparation.
	Q8: I am open to practicing questioning skills with the generative AI tool (ChatGPT).
	Q9: I consider the generative AI tool a cooperative learning teammate.
	Q10: I am willing to use the generative AI tool in future cooperative learning activities.

3.4 Procedure

1) **Pre-Course Survey**: At the start of the course, students complete a survey to establish baseline perceptions of the role of the generative AI tool in their learning.
2) **Course Integration of generative AI tools**: Generative AI tools are incorporated into the course through structured activities, such as:
   - Acting as a teaching assistant (TA) to provide answers to student questions during in-class and after-class discussions.
   - Acting as a team member to assist in group projects by generating ideas or clarifying concepts.
   - Acting as a tutor to offer personalized study guidance, including practice questions and feedback.
3) **Post-Course Survey**: At the conclusion of the course, the same survey is administered to identify changes in student perceptions after extended interaction with generative AI tools.

3.5 Data Analysis

We adopt mixed-methods approach to ensure a comprehensive evaluation of the impact of generative AI tools on learning effectiveness, motivation, and cooperative learning in a programming-related courses as shown in Table 8.

Table 8. Evaluation Methods

Category	Methods	Details
Quantitative Analysis	**Paired t-tests**	Analyze differences between pre- and post-course survey responses for normally distributed data.
	Descriptive Statistics	Calculate mean, median, and standard deviation for each survey item to summarize overall trends.
Qualitative Analysis	**Thematic Analysis**	Analyze open-ended feedback to identify recurring themes, student insights, and limitations or challenges in using the generative AI tool.
Visualization	**Graphs**	Create bar charts and line graphs to visually represent trends and shifts in perceptions, emphasizing comparisons between pre- and post-course results.

4. Results and Analysis

4.1 Quantitative Analysis

The survey results for each question for C++ programming and Python smart commerce applications are shown as in Figure 1 and Figure 2, respectively.

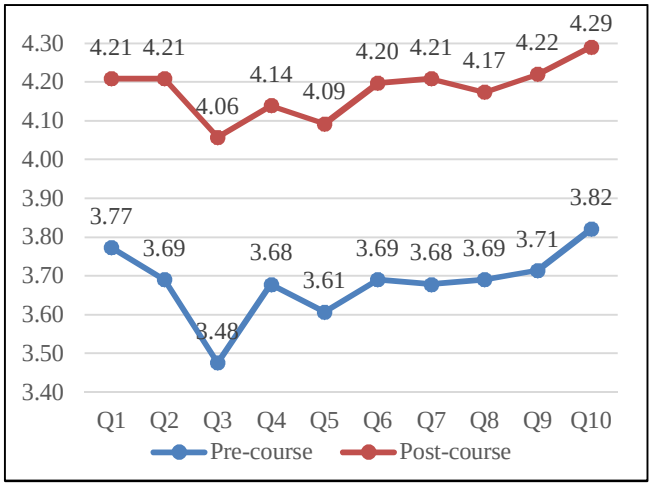

Figure 1. Survey of C++ Programming

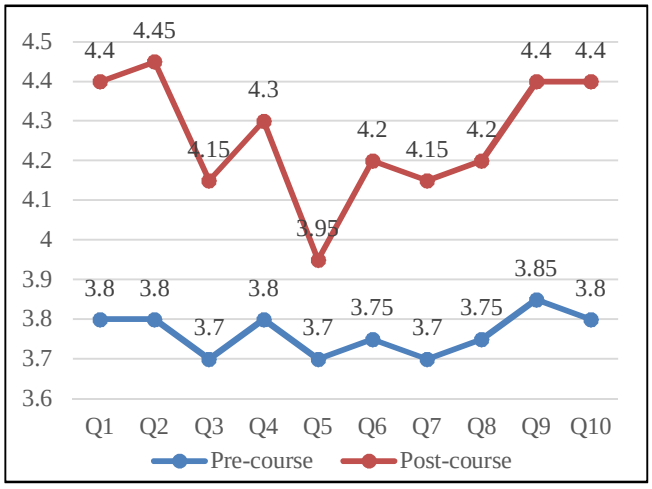

Figure 2. Survey of Python Smart Commerce Applications

The results of the pre and post mean, paired t-tests, and p-value are shown in Table 9. Both courses show statistically significant differences between pre-course and post-course scores since the p-values are much smaller than 0.05. This indicates that the post-course scores are significantly higher than the pre-course scores, suggesting the effectiveness of the courses in improving outcomes.

Table 9. Evaluation Results

Course	Pre-course Mean	Post-course Mean	Paired t-test	P-Value	Significant Difference
C++ Programming	3.682	4.18	38.8873	2.44377×10^{-11}	Yes
Python Smart Commerce Applications	3.765	4.26	13.7142	2.45057×10^{-7}	Yes

The survey comprised ten questions assessing students' perceptions of generative AI tools (ChatGPT) across areas such as guidance, personalization, and cooperation. A paired t-test was conducted to compare pre-course and post-course responses for two programming courses: C++ Programming and Python Smart Commerce Applications. In these two courses students come from diverse backgrounds: one from engineering and the other from social sciences. The analysis of results is as follows:

1) Notable Improvements Across All Questions

The paired t-tests revealed statistically significant differences ($p < 0.05$) between pre-course and post-course scores in both courses. This indicates that students' perceptions of generative AI tools improved significantly after engaging with these tools in their coursework. Specifically:

- **C++ Programming:** Students reported notable enhancements in their understanding of programming concepts and debugging techniques (e.g., Q1, Q6, Q9).
- **Python Smart Commerce Applications:** Higher post-course ratings reflected improved guidance and support in advanced topics like smart commerce and algorithm development (e.g., Q4, Q8).

2) Variations in Perceived Value Across Questions

While all questions showed improvement, some exhibited lower post-course scores than others:

- **Q3 (AI suggestions and guidance):** Despite improvements, students expressed relatively lower confidence in the tool's ability to offer valuable suggestions.
  - **Reason:** This could stem from occasional inaccuracies or generic responses from AI tools, especially for complex or niche programming problems.
  - **Improvement Methods:** Educators can encourage students to refine their AI prompts and combine AI-generated guidance with other learning resources.
- **Q5 (Personalization of responses):** Students rated the personalization capabilities of ChatGPT lower compared to other aspects.
  - **Reason:** ChatGPT may struggle to fully tailor responses to individual learning needs without sufficient context.
  - **Improvement Methods:** Provide students with guidelines on how to supply more detailed inputs to AI tools, improving the relevance and specificity of responses.

3) Positive Trends in Cooperation and Autonomous Learning

Higher ratings in questions related to collaboration and autonomous learning (e.g., Q7–Q10) highlight the value of AI tools in fostering teamwork and self-directed learning:

- **Cooperation:** Students appreciated ChatGPT as a brainstorming partner and mediator during team projects, helping to streamline ideas and resolve disputes (Q8, Q9).
- **Autonomous Learning:** AI tools empowered students to independently tackle programming challenges, explore alternative solutions, and deepen their understanding (Q7, Q10).

4) Course-Specific Observations

- **C++ Programming:** Students highlighted improvements in debugging and object-oriented programming, as these tasks benefited significantly from ChatGPT's problem-solving capabilities.
- **Python Smart Commerce Applications:** Students reported a higher reliance on AI tools for ideation, testing, and implementing algorithms for real-world applications, such as e-commerce automation.

The paired t-test results confirm that integrating generative AI tools into programming courses enhances learning outcomes, motivation, and cooperation. However, to address lower ratings in areas like guidance and personalization, educators should focus on teaching students how to interact effectively with AI tools. This will maximize the benefits of AI while minimizing its limitations.

4.2 Qualitative Analysis

To complement the statistical findings, a thematic analysis was conducted to explore qualitative insights from students' feedback. Open-ended survey responses and reflective comments in the assignments collected during the course were analyzed to identify recurring themes and patterns. Thematic coding was used to categorize the data into meaningful clusters that aligned with the research objectives.

The following key themes are identified:

1) Enhanced Learning Effectiveness:

Many students acknowledged that AI tools such as ChatGPT and Copilot helped them understand complex programming concepts and provided immediate guidance on debugging and code optimization. Students frequently noted that these tools acted as "**virtual tutors**," breaking down problems into manageable steps and offering explanations that reinforced their understanding.

2) Motivation and Engagement:

Students reported an increase in their motivation to complete assignments and projects, citing the availability of AI tools as a source of encouragement. The tools were perceived as reducing frustration during challenging tasks, allowing students to focus on creative problem-solving. Feedback highlighted that the use of AI tools made the learning process "interactive" and "less intimidating."

3) Cooperative Learning Dynamics:

AI tools were often described as valuable team collaborators, especially during group projects. They facilitated brainstorming sessions, provided code suggestions, and mediated discussions by offering neutral solutions to disagreements. However, some students raised concerns about over-reliance on these tools, which occasionally reduced direct peer-to-peer collaboration.

4) Personalized Support and Adaptability:

Students appreciated the personalized assistance provided by AI tools, particularly in helping them tailor solutions to their specific needs. However, a subset of students felt that AI responses occasionally lacked contextual understanding, which limited the effectiveness of the personalized support.

5) Concerns About Dependency:

Several students expressed concerns about becoming overly dependent on AI tools for completing assignments. They emphasized the need to maintain a balance between using AI for assistance and independently developing problem-solving skills.

The thematic analysis highlights the dual role of AI tools as both enablers and potential barriers in the learning process. While they enhance learning effectiveness, motivation, and collaboration, careful integration strategies are needed to address concerns about dependency and ensure these tools complement rather than replace traditional learning methods. Let me conclude this section with a comment from a student on her term project, translated from the original Chinese:

“In this project, I learned a lot and experienced both the helpfulness and the "flawed intelligence" of ChatGPT. There were several times when it almost drove me crazy: either it made random modifications or couldn’t understand my instructions, forcing me to rethink and change directions. I even found myself lying in bed, unable to sleep, thinking about how to write the code. But in the end, my team and I successfully completed the project, and it turned out close to what I had envisioned. Although ChatGPT almost pushed me to the brink of madness this time, I can’t deny that it provided significant assistance. In this era of technological advancement, having an additional tool can indeed be helpful as long as the tool can actually understand what you're saying!”

5. Conclusion and Future Work

This study explored the impact of generative AI tools on learning effectiveness, motivation, cooperative learning, and students’ evolving perceptions in programming courses. The findings reveal that AI tools significantly enhance perceived learning effectiveness by assisting with complex tasks such as debugging, algorithm design, and code optimization. Students reported higher confidence in their programming abilities, supported by the tools’ ability to provide immediate guidance and problem-solving strategies.

AI tools positively influenced students' motivation, offering a supportive learning environment where they could experiment with solutions and receive instant feedback. Many students indicated that the tools reduced frustration and increased engagement with challenging topics.

In cooperative learning contexts, AI tools were seen as valuable collaborators, facilitating teamwork by generating ideas, mediating discussions, and streamlining project development. However, students also

acknowledged the limitations of AI tools in providing nuanced, domain-specific insights, particularly in highly personalized tasks.

Over the course, students' perceptions of AI tools evolved from uncertainty to trust and appreciation as they gained familiarity with their capabilities and limitations. However, lower ratings in areas like guidance (Q3) and personalization (Q5) highlight opportunities for improvement in how students interact with and apply AI tools.

Future work should focus on:

1) Developing tailored training sessions to teach students how to effectively engage with AI tools for personalized responses.
2) Conducting longitudinal studies to examine the sustained impact of AI tools on learning outcomes.
3) Comparing generative AI tools with other educational technologies to evaluate their relative effectiveness.
4) Exploring how AI tools can support advanced cooperative learning scenarios, such as interdisciplinary projects.

These directions aim to further optimize the integration of AI tools into educational settings, enhancing both individual and cooperative learning experiences.

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