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COMPLETE LEARNING PLATFORM WITH GENI AI

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Abstract: Artificial intelligence (AI) is significantly reshaping the way knowledge is acquired and how collaborative learning takes place. While existing research has explored the role of AI in supporting group learning, limited attention has been given to how students actively collaborate with one another while interacting with AI tools. This study investigates this aspect by engaging thirty postgraduate students, organized into teams of three, in a project-based learning activity. Each team utilized generative AI tools such as ChatGPT, Google Gemini, and MS Copilot, along with internet resources and classroom materials, to develop their projects.

Each group selected a specific Internet of Things (IoT) domain and explored its technologies and real-world applications. They submitted a detailed report describing both their project outcomes and their interactions with AI tools, followed by a class presentation. In addition, participants completed an online questionnaire consisting of both closed and open-ended questions and took part in focus group discussions. Teams collaborated by designing prompts using five predefined collaboration strategies. Results indicated that about half of the students applied all five approaches, although most showed a preference for three specific methods. Initially, team members experienced disagreements in approximately 24% of interactions, but they were generally able to reach consensus through discussion. Students valued AI tools for their fast, structured responses, conversational style, wide knowledge base, and ability to simplify complex topics while supporting personalized learning. However, they also raised concerns regarding occasional inaccuracies, inconsistencies, and risks such as over-reliance, reduced critical thinking, outdated information, and privacy issues. Based on their experiences, students suggested that AI tools should incorporate shared and organized collaborative environments where all team members can view prompts and responses in real time. They also emphasized the importance of verifying information sources and receiving proper guidance, ensuring that AI tools are used as supportive learning aids rather than primary sources of knowledge.

Keywords: *ChatGPT*; collaborative learning; collaborative modes; collaborative prompting; *Copilot*; *Gemini*; GenAI; project-based learning; small group; team-based learning

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1. Introduction

The launch of generative artificial intelligence (GenAI) tools like *ChatGPT*, *Stable Diffusion*, and *DALL-E* in 2022 marked a significant milestone, bringing generative AI into the mainstream and unlocking new possibilities for everyday tasks and activities. GenAI is a subfield of artificial intelligence with the capability of generating text, images, videos, sound, speech, music, 3D multimedia, software code, synthetic data, or other content using generative models. These models are trained on large past data and generate new data with similar characteristics. *ChatGPT* (OpenAI, 2024) is a GenAI tool developed by *OpenAI* (released in November 2022) based on large language models (LLMs). It enables users to ask questions and obtain realistic answers of desired characteristics, such as topic, depth, length, format, style, language, and more.

So far, *ChatGPT* has been utilized across various sectors, including education. Many believe that it can improve students' learning experiences, knowledge, and skills (Deng et al., 2025). One of its most important advantages is that it can provide personalized and adaptive teaching, learning, support, and assessment (Cotton et al., 2024; Dwivedi et al., 2023; Kakhki et al., 2024; Montenegro-Rueda et al., 2023; Singh et al., 2023). In addition, it can answer questions and explain complex concepts (Lo, 2023; Montenegro-Rueda et al., 2023; Singh et al., 2023), as well as generating content, reports, articles, educational material, and assessments (Cotton et al., 2024; Dwivedi et al., 2023; Singh et al., 2023). Moreover, it can support students with disabilities (Kakhki et al., 2024), addressing individual students' needs (Montenegro-Rueda et al., 2023). For example, it can paraphrase text to a lower grade level for students with reading difficulties.

Despite the vast potential *ChatGPT* offers for education, it also raises significant concerns. Some perceive *ChatGPT* as a threat to academic integrity due to the risk of cheating and plagiarism (Cotton et al., 2024; Dwivedi et al., 2023; Singh et al., 2023). For example, teachers would encounter difficulties recognizing students' work from AI- generated content (Dwivedi et al., 2023). Additionally, there are concerns about inaccuracies, misinformation, fake news, and biased data in its responses (Dwivedi et al., 2023; Lo, 2023; Singh et al., 2023). Furthermore, there are also risks regarding data privacy and security (Dwivedi et al., 2023; Montenegro-Rueda et al., 2023), copyright, and lack of transparency (Dwivedi et al., 2023).

While GenAI tools are increasingly integrated into education, there is limited empirical research on how students communicate and collaborate with peers while using GenAI tools (Gilson et al., 2023; Tan et al., 2022). The existing studies often focus on individual AI inter- actions rather than group dynamics, leaving a gap in understanding which collaborative modes students use and prefer when working with GenAI tools.

In this context, we chose to investigate students' experiences, preferences, learning, views, and suggestions in a GenAI-powered collaborative project-based learning envi- ronment. Special attention is given to students' preferences regarding various ways of collaboratively designing prompts. Collaborative learning is when students work together in groups to reach a common goal, such as solving a problem, creating a product, or accom- plishing a task (Dillenbourg, 1999; Laal & Laal, 2012). By working as a team, students can learn from each other, exchange ideas, knowledge, skills, and improve their knowledge and skills. In collaborative learning, learners share ideas, construct knowledge together, and form a shared understanding of various subjects (Soller et al., 2023). Students can use various communication approaches to work together, handle disagreements, and make decisions. Understanding how students interact during collaborative activities is crucial for designing more effective educational experiences. Research in this area can reveal how students interact, communicate, make decisions, solve problems, perform tasks, etc. Therefore, this study aims to identify students' preferences and perceptions related to collaborative modes, communication tools, and their learning while working with GenAI tools to implement project-based learning activities. Furthermore, it aims to discover the strengths, weaknesses, opportunities, and obstacles of using GenAI tools in education. The results of the study may inform the development of effective pedagogical approaches and technological tools that may enhance student engagement and learning outcomes in group settings.

In the following sections, we further explore previous studies on AI and collabora- tive learning and present the findings of our empirical research on the ways of students' collaboration during their learning process, facilitated and supported by GenAI tools.

2. Previous Studies

Most previous studies about artificial intelligence (AI) and collaborative learning acknowledge human–AI collaboration as a central theme (Dwivedi et al., 2023; Liu et al., 2023; Lo, 2023; Luther et al., 2024). In other words, the user (e.g., student, teacher) collabo- rates with the AI tool in performing a task (e.g., writing a report, assisting programming, generating assessments, solving a problem). For example, Elson et al. (2018) examined trust and dependency on human–AI collaboration. Furthermore, Nah et al. (2023) discussed GenAI–human collaboration and emphasized that human values and needs should guide the design of GenAI. Pavlik (2023) considered the implications of human–*ChatGPT* collab- oration for journalism and media education. Luther et al. (2024) also found that people who collaborated with *ChatGPT* to write a text about prohibiting alcohol in public were satisfied with *ChatGPT*'s responses. Similarly, students found *ChatGPT* to be a user-friendly, time-saving, fast, useful, and helpful tool for online market research and website design and development (Economides & Perifanou, 2024a, 2024b). Finally, Li et al. (2024) examined the impact of human–GenAI collaboration on AI literacy, human agency, creativity, and copyright.

Several previous studies have also explored the use of AI for supporting collaborative learning (Haq et al., 2021; Kasepalu et al., 2022; Lewis, 2022; Ouyang & Zhang, 2024; Ponte et al., 2023; Rudolph et al., 2023; Tan et al., 2022; Wang & Wang, 2022; Zheng et al., 2024). These studies have used AI for supporting either the management of collaborative learning (e.g., assigning members to groups, developing assignments for groups) or the learning process (e.g., analyzing the interactions of group members and making recommendations to groups, evaluating groups' work). More specifically, previous studies on using AI to support the management of collaborative learning include the following. Haq et al. (2021) as well as Wang and Wang (2022) proposed methods for assigning students into groups based on their personal characteristics. Moreover, Kasepalu et al. (2022) developed an AI assistance tool to facilitate teachers in supporting collaborative learning. Furthermore, Rudolph et al. (2023) used *ChatGPT* to generate collaborative problem-solving scenarios for students to work on in groups. Correspondingly, previous studies on using AI to support the learning process include the following. Lewis (2022) proposed multimodal large language models to offer feedback to learners based on their collaborative behav- iors. Similarly, Tan et al. (2022) reviewed AI techniques to analyze group outcomes and interactions in order to provide feedback to improve interaction and collaboration. Ponte et al. (2023) also used *ChatGPT* to provide personalized formative feedback to groups. Although participants had positive opinions regarding the feedback, only three groups used the feedback to improve their plans. In a literature review, Ouyang and Zhang (2024) presented studies that employed AI to evaluate group interactions and group performance. Finally, Zheng et al. (2024) proposed the use of AI for providing automated assessment results and personalized recommendations to enhance collaborative knowledge building. Empirical research on using *ChatGPT* to facilitate collaborative learning is limited, since most studies are theoretical, as multiple authors have noted (Das & Madhusudan, 2024; Dwivedi et al., 2023; Fauzi et al., 2023; Liu et al., 2023; Montenegro-Rueda et al., 2023). In fact, many authors (Følstad et al., 2021; Gilson et al., 2023; Tan et al., 2022) emphasized the need for further research on collaborative learning using chatbots. For example, Zhu et al. (2023) stated that there are no empirical studies on collaborative interdisciplinary learning, and they suggested that the use of *ChatGPT* should be tailored to the specific educational subjects and students' characteristics. Thus, the current study explores the collaborative use of GenAI tools by students while implementing their group projects. The students used the free version of *ChatGPT* (OpenAI, 2024), as well as *Google Gemini* (Google, 2024) and *MS Copilot* (Microsoft, 2024), which have real-time access to the internet. More specifically, this study aims to answer the following research questions (RQs):

RQ1: *How do university students communicate and collaborate with their team classmates while interacting with GenAI tools? Which collaborative mode do team members prefer while interacting with GenAI tools?*

RQ2: *What do university students like, worry, and recommend about GenAI tools?*

3. Methodology

3.1. Research Design

This research paper employs between-method triangulation (Carter et al., 2014; Denzin, 1978), combining data triangulation (multiple data sources) and methodological triangu- lation (multiple methods). It is also a mixed-method research work (Johnson et al., 2007), combining qualitative (e.g., participant observation, focus groups, and document analysis) and quantitative research (e.g., surveys and questionnaires).

The primary aim of this study is to investigate how members of a team (small groups) collaborate among themselves while working with GenAI tools to develop their project. This is a topic on which there is no prior research. The exploratory case study method is appropriate for this research because it allows for an in-depth, contextual analysis of a contemporary phenomenon within its real-life setting. Given the novelty of *ChatGPT* and its applications in educational contexts, an exploratory case study is ideal for generating insights and hypotheses that can inform future research. An exploratory study is a research process that investigates topics other researchers have not yet studied in depth. Exploratory research is conducted during the early stages of a research study, usually when a researcher wants to test the feasibility of conducting a more extensive study (Savin-Baden & Major, 2023).

The case was selected based on its relevance to the current educational trends and the increasing use of GenAI tools by students. A case study is characterized as an examination of the uniqueness and complicacy of an individual case, aimed at understanding its actions within significant contexts (Stake, 1995).

3.2. Context and Participants

During spring 2024, thirty (30) postgraduate students took a compulsory course in Computer Networks in the postgraduate program of Information Systems at the University of Macedonia, Thessaloniki, Greece. Most of the students in this postgraduate program are graduates from departments in Business Administration, Economics, Finances, Accounting, and other Social Sciences at universities in Greece. This is a first-year introductory course in Computer Networks that employs project-based learning as a pedagogical approach. Project-based learning refers to students actively engaging in real-world projects through investigation and authentic output creation in order to learn (e.g., Bell, 2010; Sukacke˙ et al., 2022).

The course requirements include the development of a small-group (three members) project that accounts for 50% of the final grade. This study uses the words "teams", "small group", or "group" (terms usually used by previous studies) interchangeably to mean a small group of students.

During the first two weeks of the semester (February 2024), the course content covered internet of things (IoT) technologies and applications in various sectors of the economy and society. Initially, the teacher had limited information with respect to students' previous knowledge and skills. During March and April 2024, the students freely formed teams of three members and developed a collaborative project. Each team selected a specific IoT application area (different from those selected by other teams), investigated the IoT technologies (e.g., devices, networks, protocols, software) and real-world cases in this area, and produced a report and a presentation. More specifically, students chose to investigate IoT application areas like *Smart Homes*, *Smart Buildings*, *Smart Cities*, *Smart Tourism*, *Smart Agriculture*, *Smart Education*, etc.

Based on at least six (6) criteria, each team compared at least four (4) real-world cases as well as sensor network deployments for their specific IoT application area. In addition, they developed a Strengths, Weaknesses, Opportunities, and Risks (SWOT) analysis. Students found information on the specific IoT application area in the course resources (e.g., teacher's presentations, previous students' reports, open books, case studies, industry reports, research papers) on the university's learning management system and on the internet. It was also required that students use GenAI tools, such as the free version of *ChatGPT* as well as *Google Gemini* and *MS Copilot*, which have real-time access to the internet. The team members collaborated face to face and/or online using collaboration tools (e.g., *Google Docs*, *Padlet*, *Miro*), videoconferencing (e.g., *Zoom*, *Google Meet*), messaging, and telephone. During their interaction with the GenAI tools, each team followed five (5) different modes of collaboration among themselves (more on this in the following section). Then, each team created a report and a presentation (about 30 slides) that described their work and results and uploaded them on the learning management system of the university. In addition, the team's report included an Appendix with the prompts (and the revised prompts) given to GenAI tools and the responses of GenAI tools. The final content featured in their report, and the presentation ought to be a combination of information found in the course resources, on the internet, and enhanced versions of GenAI tools' responses.

During May and June 2024, each team presented their project in class and answered teacher's questions about their work and results. At the end of each class, a focus group discussion was held with all students and the teacher to discuss the students' outputs, the process of implementing their projects, their collaboration, and the use of GenAI tools. Finally, each student had to answer an online questionnaire regarding their experiences, preferences, views, and suggestions in using the GenAI tools and collaborating with their team members.

3.3. *Data Collection Methods*

The data collection methods included multiple methods and sources to ensure a holistic view of students' perceptions, practices, experiences, and recommendations. They included students' answers to an online questionnaire on *Google Forms*, students' presentations in class, students' written reports, focus group discussions in class, as well as teacher's direct observation and grading of students' presentations and written reports. Ethical approval was issued by the University of Macedonia.

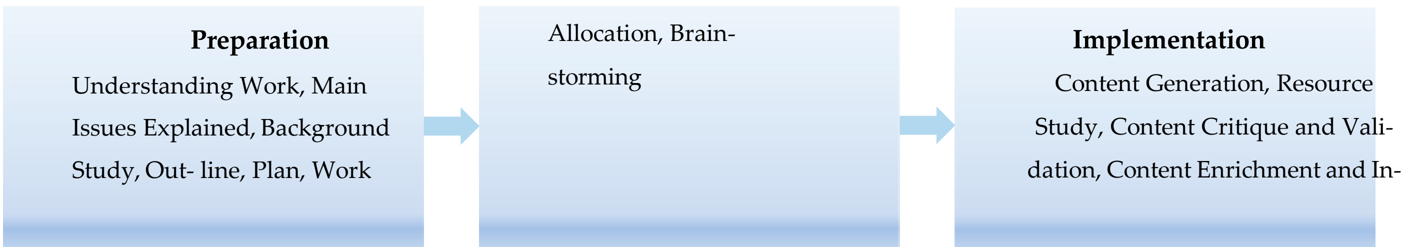
4. Collaborative Project-Based Learning

4.1. *Methodology for Collaborative Project Development Using GenAI*

All students were invited to use the following *Collaborative Preparation*, *Implementation*, *Revision (CoPIR)* methodology to develop their team project (or task, assignment, work) using GenAI (Table 1, Figure 1). Initially, they had to understand their project and the issues associated with it, as well as to plan their work and assign roles and responsibilities to each member. Then, they had to collaboratively develop the various parts of their project. Finally, they had to evaluate, refine, and assure the quality of the final output.

Table 1. Collaborative Preparation, Implementation, Revision (CoPIR) methodology for project development using GenAI.

Phases	Collaborative Preparation, Implementation, Revision (CoPIR) Methodology Each Member	The Team
1. PREPARATION	- reads and **understands** the project (e.g., requirements, resources, tools, format, deadlines, objectives, expected outcomes, evaluation criteria); - prompts (iteratively) GenAI to **explain** the main topic and keywords (e.g., concepts, theories, methods, systems, variables) of the project; - studies and shares **background** information from reliable sources (e.g., books, lecture notes, etc.).	- discusses, understands, and **agrees** on the work; - prompts (iteratively) GenAI to suggest an **outline (structure)** of the work to be conducted; discusses and agrees on the outline; - prompts (iteratively) GenAI to suggest **a plan (roadmap, steps)** and **timeline** for developing the project; reviews and revises the plan and timeline; - prompts (iteratively) GenAI to suggest **roles, responsibilities, work allocation,** etc., to the team members; reviews, revises, and assigns roles, responsibilities, and parts of the work to each member; - prompts (iteratively) GenAI to suggest ideas (**brainstorming**) and initial steps for starting the work; - reviews and revises the initial steps.
2. IMPLEMENTATION	- (independently or collaboratively) prompts (iteratively) GenAI to suggest content for their part; collects **GenAI-generated content for their part**; - (independently or collaboratively) prompts (iteratively) GenAI to suggest reliable resources; **finds** and **studies** the **GenAI-suggested resources** for their part; - **searches, finds, studies,** and **shares extra reliable resources** (e.g., books, articles, lecture notes, reports, websites, etc.) for their part; - **compares, critiques,** and **validates** the **GenAI-suggested content and resources** (cross-checks with reliable resources; removes misinformation and bias) for their part; - **combines, edits, enriches,** and **shares** the GenAI-generated content and independently found content for their part;	- **integrates, edits,** and **improves** all parts of the content;
3. REVISION		- **evaluates, validates,** and **revises** the **integrated content** (cross-checks with reliable resources; removes misinformation and bias); - prompts (iteratively) GenAI to **improve** the **writing** (e.g., correct grammar, syntax, format, summarize, enhance clarity, coherence, consistency, etc.); - prompts (iteratively) GenAI to **evaluate** the **final output**; - **reviews** and **revises the final output** and **ensures academic integrity** (e.g., citations of others' work or GenAI-generated content); - prompts (iteratively) GenAI to **create** a **presentation**; - **reviews** and **revises** the **presentation.**



tegration

Revision

Evaluation, Validation, and Revi- sion of Integrated Content, Writing Improvement, Evaluation and Re- vision of Final Output

Figure 1. The flow of the Collaborative Preparation, Implementation, Revision (CoPIR) methodology.

4.2. Collaborative Prompting When Using GenAI Tools

GenAI tools can support collaborative learning in various ways, anywhere, syn- chronously (in real time) or asynchronously. They can make recommendations to each independent team member, as well as to all members as a team. Students interacted with GenAI either independently or collaboratively. The three members of each team collabo- rated among themselves during their interaction with a GenAI tool using the following collaborative modes:

(1) *Collaborative Mode #1 (one in a row)*: A team member independently gives his/her own initial prompt to the GenAI tool (Figure 2). Based on the response (received by all members) of the GenAI tool, the second member revises the initial prompt and gives his/her own new prompt to the GenAI tool. Then, based on the new response (received by all) of the GenAI tool, the third member gives his/her own new prompt to the GenAI tool. Finally, all team members discuss the response (received by all) of the GenAI tool and arrive at the final result.

(2) *Collaborative Mode #2 (team-oriented)*: All team members discuss and agree to give a joint initial prompt to the GenAI tool (Figure 3). The team leader gives the joint prompt to the AI tool. Based on its response (received by all), they discuss again and agree to give a joint revised prompt to the GenAI tool. The team leader gives the joint revised prompt to the GenAI tool. And in the third iteration, members discuss the response (received by all) of the GenAI tool and agree on a joint new revised prompt. The leader gives the joint new revised prompt to the GenAI tool. Finally, all team members discuss the response (received by all) of the GenAI tool and arrive at the final result. This is the most straightforward mode of collaboration. Team members continually work together.

(3) *Collaborative Mode #3 (member then team)*: Each team member independently gives his/her own prompt to the GenAI tool (Figure 4). All team members discuss all GenAI tool responses (received by all) and agree on a joint revised prompt. The team leader gives the joint revised prompt to the GenAI tool. And in the third iteration, team members discuss the response (received by all) of the GenAI tool and agree on a joint new revised prompt. The leader gives the joint new revised prompt to the GenAI tool. Finally, all team members discuss the response (received by all) of the GenAI tool and arrive at the final result. In this mode, initially, each team member independently gives a prompt in order to explore different views. Then, the team members collaborate to design joint revised prompts. Finally, all team members decide on the final result.

(4) *Collaborative Mode #4 (team to member)*: Each team member independently gives his/her initial prompt to the GenAI tool (Figure 5). All team members discuss each result (received by all) of the GenAI tool and propose a revised prompt to each member. Each member independently decides on their own revised prompt and gives it to the GenAI tool. And in the third iteration, all team members discuss each response (received by all) of the GenAI tool and suggest to each member a revised prompt. Each member independently decides on their own revised prompt and gives it to the GenAI tool. Finally, all team members discuss the responses (received by all) of the GenAI tool and arrive at the final result. In this mode, each team member independently gives a prompt, taking into consideration the advice of their colleagues. Finally, all team members decide on the final result.

(5) *Collaborative Mode #5 (independently, cooperatively)*: The work is divided into three parts. Each team member works independently from the other members on a different part of the work. Each team member interacts alone with the GenAI tool to complete their part (Figure 6). Finally, all team members discuss the responses of the GenAI tool and agree on the final result. This is the simplest mode of collaboration or cooperation, where team members collaborate only to combine their parts.

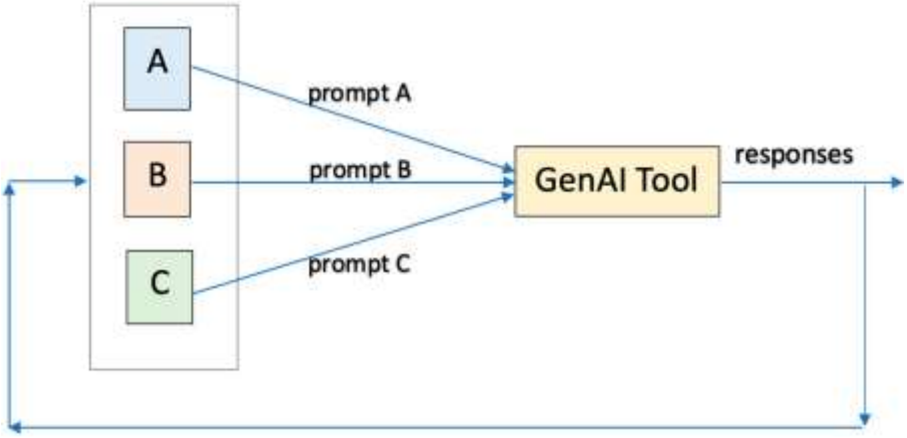


Figure 2. Collaborative Mode #1 (one in a row) of team members A, B, and C when interacting with the GenAI tool.

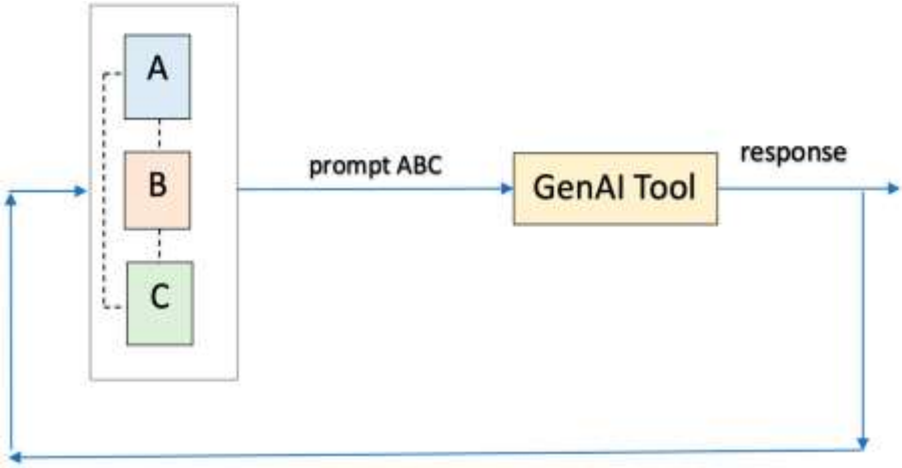


Figure 3. Collaborative Mode #2 (team-oriented) of team members A, B, and C when interacting with the GenAI tool.

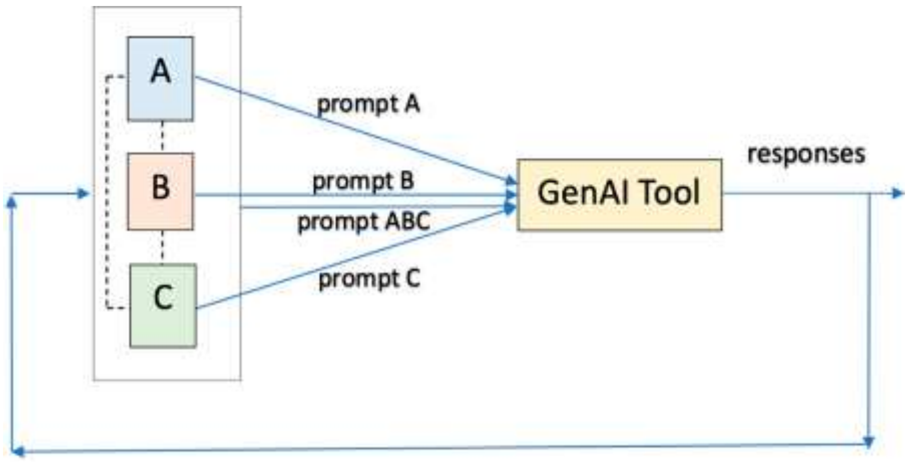


Figure 4. Collaborative Mode #3 (member then team) of team members A, B, and C when interacting with the GenAI tool.

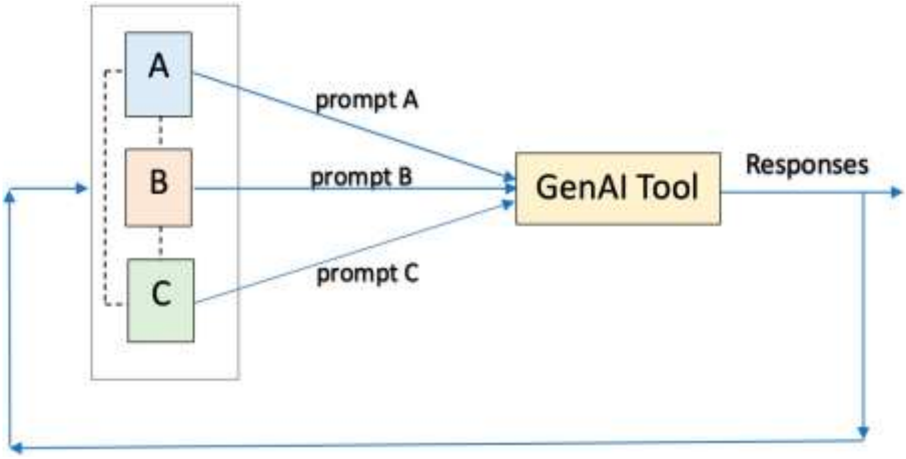


Figure 5. Collaborative Mode #4 (team to member) of team members A, B, and C when interacting with the GenAI tool.

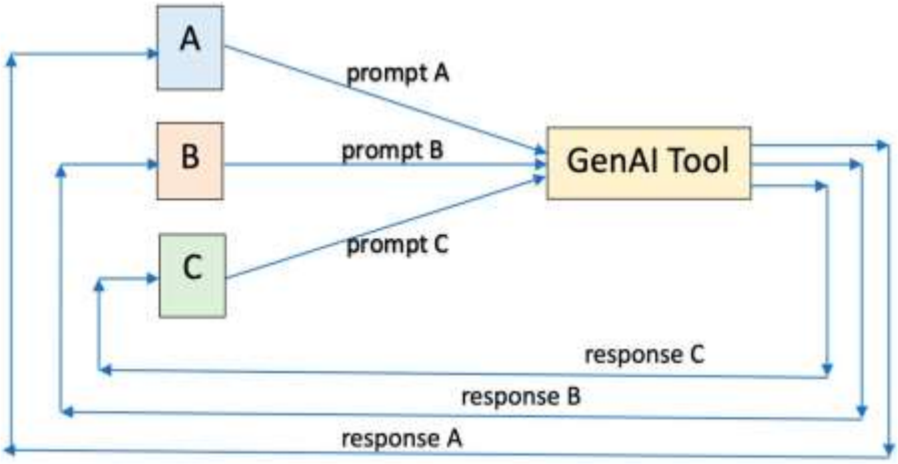


Figure 6. Collaborative Mode #5 (independently) of team members A, B, and C when interacting with the GenAI tool.

All teams were instructed to use all five collaborative modes during their interaction with a GenAI tool.

5. Data Analysis and Results

This mixed-methods study employed both qualitative and quantitative analyses. For the quantitative analysis, descriptive statistics summarized the data collected from students' responses to the survey's closed-ended questions. Also, Spearman's Rho tests and Pearson correlations were used for inferential statistical analysis. In terms of qualitative analysis, inductive thematic analysis (Braun & Clarke, 2006, 2023) was used to analyze students' answers to the open-ended questions of the online questionnaire and their views expressed during the focus group discussions conducted in class. The aim of the content analysis was to identify themes and patterns in students' views and experiences with regard to the collaborative modes and the GenAI tools.

5.1. *Quantitative Results*

The survey questionnaire consisted of three parts: (i) demographics; (ii) evaluation of collaborative modes; (iii) open-ended questions. The questionnaire was uploaded on *Google Forms*. It was pilot-tested by three colleagues to ensure clarity and comprehensibility. Convenience sampling was adopted to collect responses from students, since this was a small-scale initial exploratory study. Students were invited both in class and by announcements via the course space at the university's learning management system. The survey was conducted following the ethical principles of research approved by the University of Macedonia Ethical Committee.

5.1.1. Demographics and General Characteristics

Thirty (30) postgraduate students enrolled in the compulsory course Computer Net- works in the postgraduate program in Information Systems at the University of Macedonia, Thessaloniki, Greece. Half of the students were female. Most students (63.3%) were between 23 and 27 years old. In addition, 6.6% of students were 22 years old or younger; 16.7% were between 28 and 32 years old; 3.3% were between 33 and 37 years old; and 10% were 38 years old or older. Regarding the daily use of the internet, 30% of students used it for 2–4 h, 30% used it for 4–6 h, 20% used it for 4–8 h, and 20% used it over 8 h. To develop their team's project, almost all students (n = 29) used the free version of *ChatGPT*, while many students (n = 23) also used *Gemini* and/or *Copilot* (which have real-time internet access).

5.1.2. Students' Preferences Regarding Collaborative Modes

In general, students have diverse skills and preferences: some like highly structured collaborative environments, while others prefer more flexible and independent work. By experimenting with different organizational structures of their collaboration, students can investigate a range of collaborative skills, such as communication, teamwork, conflict resolution, and leadership. Furthermore, it is important for them to be able to adapt their collaboration strategies, since their personal state and their project's evolution may change over time. Half of the students (50%) used all five collaborative modes (Section 4.2). More specifically, 63.3% of students collaborated among themselves using *Mode #1*, 86.7% used *Mode #2*, 76.7% used *Mode #3*, 83.3% used *Mode #4*, and 80% used *Mode #5* (Table 2). Regarding the teams, one team used only one collaborative mode (*Mode #5*), one team used two modes, one team used three modes, two teams used four modes, and five teams used all five modes.

Table 2. Students' preferences regarding collaborative modes while interacting with *ChatGPT* (n = 30 students).

Personally, I Like and Prefer Collaborative Mode	**Not Used**	**Strongly Disagree 1**	**Disagree 2**	**Neutral 3**	**Agree 4**	**Strongly Agree 5**	**Mean**	**SD**
1: one in a row	11	3	4	9	3	0	2.63	0.96
2: team-oriented	4	2	0	6	11	7	3.80	1.10
3: member then team	7	2	4	6	8	3	3.26	1.18
4: team to member	5	1	3	7	10	4	3.52	1.05
5: independently	6	1	5	2	9	7	3.67	1.24

Most students liked and preferred *Collaborative Mode #2* (team-oriented) (M = 3.80, SD = 1.10). More specifically, they agreed (36.7%) and strongly agreed (23.3%) that they liked and preferred *Collaborative Mode #2*. Few students (10%) liked and preferred *Collabora- tive Mode #1* (one in a row) (M = 2.63, SD = 0.96) (Table 2). Their preferences for the remaining collaborative modes are shown below: *Mode #5* (M = 3.67, SD = 1.24), *Mode #4* (3.52, SD = 1.05), and *Mode #3* (M = 3.26, SD = 1.18). More specifically, they agreed (26.7%) and strongly agreed (10%) that they liked and preferred *Collaborative Mode #3* (member then team). They agreed (33.3%) and strongly agreed (13.3%) that they liked and preferred *Collaborative Mode #4* (team to member). They agreed (30%) and strongly agreed (23.3%) that they liked and preferred *Collaborative Mode #5* (independently).

Overall, students mostly favored and preferred *Collaborative Mode #2*, followed by *Collaborative Modes #5* and *#4*.

During the implementation of their project, students had to make some decisions on various issues. They discussed each issue, presenting their arguments, and reached an agreement. On average, they initially disagreed 24% of the time but eventually reached an agreement. More specifically, nineteen students (65.5%) initially disagreed on 20% of the issues, and eight students (27.6%) initially disagreed on 40% of the issues.

Students agreed that they learned a lot about their IoT application topic during their project implementation (M = 4.6, SD = 0.5), as well as about other IoT application topics from the presentations of other teams' topics (M = 3.97, SD = 0.85) (Table 3). Similarly, they agreed (M = 4.4, SD = 0.56) that their team partners learned a lot about their IoT application topic during their project implementation.

Table 3. Students' learning during collaborative development of their project.

Students' Learning During Collaboration	Strongly Disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly Agree 5	Mean	SD
During the development of our project, I learned a lot about the topic of our project.	0	0	0	12	18	4.6	0.50
During the development of our project, I believe that members of my team learned a lot about the topic of our project.	0	0	1	16	13	4.4	0.56
I learned a lot from the presentations of other teams' project topics.	0	2	5	15	8	3.97	0.85

More specifically, twelve students (40%) agreed and eighteen students (60%) strongly agreed that they learned a lot about their IoT application topic during their project imple- mentation. Similarly, sixteen students (53.3%) agreed and thirteen students (43.3%) strongly agreed that their team partners gained a lot of knowledge about their IoT application topic during their project implementation; one student neither agreed nor disagreed. In fact, students believed that they learned slightly more than their team partners. When conducting Spearman's Rho tests to measure the strength of association between students' project grades and their learning perceptions, it was found that they cannot be considered statistically significant. In other words, it cannot be documented that students who believed they learned a lot about their IoT application topic also achieved a high grade for their project. This difference may be due to the fact that students' initial knowledge regarding IoT applications was low, and although they learned a lot about IoT applications, they did not reach very high levels of knowledge. It is also possible that students overrated their learning.

When performing additional statistical analyses, it was found that the association between their perceptions that they learned a lot and that their team members also learned a lot could be considered statistically significant (Spearman's Rho test: rs = 0.63, p (two-tailed) = 0.0002; Pearson correlation coefficient: r(27) = 0.58, $p = 0.001$).

Overall, their agreement was slightly lower with regard to their learning about other IoT application areas from project presentations by other teams. Fifteen students (50%) agreed and eight students (26.7%) strongly agreed that they learned a lot from the pre- sentations of the other teams. The remaining five students (16.7%) were neutral, and two students (6.7%) disagreed that they learned from other teams' presentations.

5.2. *Qualitative Results*

The qualitative results are based on three sources of data: (i) students' responses to the open-ended questions (Appendix A); (ii) students' views expressed during three focus group discussions in class; and (iii) students' reports and presentations. Note that students were required to explicitly state their prompts to GenAI in their reports. The data on students' responses to open-ended questions and focus group discussions were analyzed following the six stages of thematic analysis (Braun & Clarke, 2006, 2023): (1) familiarization with the data after reading them several times; (2) creating initial codes through open coding by extracting and isolating quotes verbatim; (3) looking for themes under the discussion topic and emerging ones based on data extracts; (4) going over initial codes and finding any latent themes and combining them into preliminary themes; (5) revising and developing themes in later iterations; and (6) further consolidating the identified themes under fewer themes.

5.2.1. Prompting

Students mostly asked *ChatGPT*, *Gemini*, and *Copilot* for information and content creation. They asked them simple prompts like "*what is . . .?*", "*what does . . .?*", "*which . . .?*", "*give me . . .*", "*describe . . .*". Regarding specific IoT application areas (domains) and sub- areas (sub-domains), they asked for definitions, problems, requirements, goals (objective), categories (types), methods (strategies), examples, applications, services, case studies, best practices, system architectures, components (e.g., devices, sensors, actuators, processors, network technologies, protocols, software, software development platforms), benefits, challenges, opportunities, risks, evaluation (selection) criteria, references (bibliography), etc. Although almost all students asked revised prompts to the GenAI tools, very few students asked them for text refinement (e.g., "*enhance . . .*", "*improve . . .*", "*proofread . . .*"), text summarization (e.g., "*summarize . . .*"), or clarifications and explanations (e.g., "*clarify . . .*", "*explain . . .*"). Usually, students copy-pasted what they liked from the tools' responses into their work. Unfortunately, students did not ask any advanced prompts like "*why does . . .?*", "*evaluate . . .*", "*critique . . .*", "*compare. . .*", etc. They did not ask for prompts to design diagrams either. However, they used some other GenAI tools to generate pictures.

5.2.2. Collaboration Among Team Members While Working with GenAI Tools

The three members of each team collaboratively interacted with GenAI tools. Students were required to experiment with five collaborative modes and report on their prefer- ences. Most students showed a slight

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preference toward *Collaborative Mode #2*, followed by *Collaborative Modes #5* and *#4*. Students also answered an open-ended question in order to explain the reasons for preferring a collaborative mode, the problems that they faced in each collaborative mode, and their suggestions. Students pointed out the following important criteria for choosing a collaborative mode: (1) the speed of producing useful results, (2) the effectiveness of producing useful results, (3) the collective way of thinking,
(4) the knowledge exchange between team members, and (5) the autonomy of each team member.
For example, the following are students' answers: "*In the 1st, 3rd, 5th Collaborative Modes, I liked the speed of getting results. In the 2nd and 4th Collaborative Modes, I liked the collective way of thinking*"; "*Regarding the 5th Collaborative Mode, I liked that everyone had the autonomy to choose the questions/prompts they would ask themselves with ChatGPT, with whatever changes they wanted to make, but at the end there was a collaborative decision where we all made corrections and arrived at a final result. I didn't face any problem during my collaboration. To improve it maybe I would discuss with my team from the beginning some initial ideas about the prompts, before the individual interactions with ChatGPT to have a greater consistency in the result*"; "*In the 2nd Collaborative Mode, I liked that at the same time we could all as a team make decisions about the questions that we asked to ChatGPT and about the work in general. In the 3rd method of collaboration, what I liked is that everyone worked at their own pace and at the times that suited them and focused more on their subject*".

Finally, they would like GenAI tools to provide a shared discussion space for a group of people who collaboratively ask prompts. In this way, all group members could see the prompts given by others, as well as GenAI tool's response. Maintaining an organized discussion history shared between all team members would allow them to easily refer to previous prompts and answers. This feature would help them keep track of their progress and development without losing continuity.

5.2.3. Communication Among Team Members

Students utilized a variety of digital tools and platforms to facilitate their team commu- nication and collaboration. Almost all students preferred and extensively used face-to-face communication and collaboration. However, during Easter holidays and at weekends, they could only communicate online or by phone. Also, initially, some teams held online com- munication but later shifted to face-to-face communication and collaboration. One student stated, "*We had a pretty good cooperation, the first meetings we did remotely without a problem, but the work became even more immediate and efficient when we met in person*". Another student pointed out, "*The zoom platform especially for the first discussions was the best communication solution for us because of our schedule, but the live (face-to-face) meetings were necessary to get a team, collaborative result*".

The most commonly mentioned methods included messaging apps like *Messenger* and *Viber*, videoconferencing tools such as *Google Meet*, *Zoom*, and *Discord*, as well as cloud- based file-sharing services like *Google Drive* (Table 4). They mostly liked the convenience offered by these digital tools. Most users used more than two tools. Usually, they used one tool for communication (e.g., *Viber*) and another tool for sharing their work (e.g., *Google Drive*).

Table 4. Frequency of use of communication and collaboration tools.

Zoom	**Google Meet**	**Discord**	**Facebook Messenger**	**Viber**	**Google Drive**	**Instagram**	**Email**	**Phone**

Frequency	9	6	3	5	11	2	5	4
10								

Students generally expressed satisfaction with these communication channels, high- lighting their familiarity, ease of use, and effectiveness in enabling real-time communication and collaboration. They particularly valued screen sharing and simultaneous document editing offered by videoconferencing tools like *Zoom*, *Google Meet*, and *Discord*. For example, one student liked *Google Meet* "*because it is directly accessible due to our academic Gmail, also its screen sharing works perfectly*". Another student underlined their preference for "*Discord call, immediacy and the possibility of screen sharing, which helped us reach a common conclusion*".

Finally, students mentioned some problems with the tools, as well as their internet and Wi-Fi connections. One student said, "*The Zoom didn't have a good connection and it stuck a lot*".

5.2.4. Advantages/Capabilities/Strengths of GenAI Tools

Most students mainly highlighted the GenAI tools' ability to provide quick, immediate responses as a key strength. They appreciated how the AI tools could deliver clear, concise, and comprehensible answers. Several students valued the GenAI tools' natural responses and their ability to iteratively refine their responses. Students also liked the GenAI tools'

capacity to handle diverse topics and explain complex topics in simple terms. They noted the tools' ability to structure information effectively, such as creating bullet points and outlines, making content more reader-friendly (e.g., "*It helped us narrow down the information we found to fit into our work in the form of bullets to make it more reader-friendly*").

In fact, different tools offered unique strengths: *Gemini* was praised for its image analysis capabilities and direct internet access, while *Copilot* was noted for table handling and image creation. Students also valued *Gemini*'s and *Copilot*'s ability to provide real references. The ease of use and time-saving aspects were consistently mentioned.

5.2.5. Weaknesses/Limitations/Shortcomings of GenAI Tools

Students' main concerns were the accuracy, reliability, and up-to-dateness of GenAI responses. Students noted that answers sometimes contained mistakes, ambiguities, or outdated information that required cross-checking. Many students specifically highlighted *ChatGPT*'s lack of source citations and references as a significant limitation (e.g., "*The information it gives is not always 100% valid and needs cross-checking. It could, for convenience, give the sources from which its answers come from*"). Students pointed out problems such as overly general or chatty answers, similar responses even when the questions were reformulated, as well as inconsistent understanding of question context and intent.

Additionally, technical limitations and performance issues comprised another major category of concerns. Regarding *ChatGPT*, students reported the lack of direct access to the web and current information and inability to process images. Language and communication challenges were also notable, including problems with non-English language processing. Students suggested that regular updates to the knowledge base and improved source attribution would significantly enhance the tools' educational value.

5.2.6. Opportunities and Suggestions for Using GenAI Tools for Learning and Work

Students viewed GenAI tools as personal assistants that can serve multiple educational and professional purposes. In educational contexts, they highlighted the tools' potential as personal tutors, helping students understand complex concepts by breaking them down, providing examples, and explaining them in simple terms. The tools were seen as particularly valuable for personalized learning, offering interactive experiences and the ability to adapt content to individual student needs. Students also emphasized the tools' capacity to spark curiosity (e.g., "*It can give you food for thought and additional ideas to look into later on your own*") and guide further research, suggesting that they could serve as smart encyclopedias, providing instant access to wide-ranging information.

For professional applications, students noted the tools' efficiency in various tasks, including writing reports, preparing presentations, drafting emails, and assisting with research (e.g., "*It provides instant access to a wide range of information, enabling faster research and data aggregation. It assists in writing reports, articles, essays and other texts by providing suggestions and improvements. It provides help in writing resumes and cover letters, making it more professional and effective*"). However, a crucial theme emerged regarding proper usage: students consistently emphasized that GenAI tools should serve as auxiliary tools rather than primary sources (e.g., "*It should just have an advisory role and not a central role in learning*"). They suggested using these tools with careful consideration, particularly in educational settings, where teachers must ensure students genuinely understand the material rather than simply copy information. Specific recommendations included developing more student-friendly interfaces, incorporating interactive exercises and games, and integrating the tools as digital tutors to provide supplementary explanations while maintaining the teacher's central role in the learning process.

Obstacles and Risk Mitigation When Using GenAI Tools for Learning and Work Students identified several significant risks and barriers to using GenAI tools effec-
tively in learning and work environments. The primary concern was the potential for
passive learning and reduced critical thinking, with many students worried about users simply copying information without properly understanding or verifying it. They specifi- cally highlighted the risk of students becoming overly dependent on "ready-made" answers. Students also noted that *ChatGPT*'s outdated information and the lack of access to scientific articles and proper source citations could lead to problematic decisions (e.g., "*It does not have access to scientific articles so the results shown do not assure me that they are fully verified. Also, I may have the same answers as someone else who has used it*"). The danger of misinformation and the need for fact checking were repeatedly emphasized. Additional concerns included data privacy risks, inequality issues (due to the high costs of accessing advanced GenAI tools), and the tools' potential to deviate from topics or provide overwhelming amounts of information.

To mitigate these risks, students suggested several approaches: implementing strict usage guidelines in educational settings, verifying information through multiple reliable sources, using more specific prompts to obtain better responses, and maintaining human oversight in the process. They emphasized that GenAI tools should be used as supplemen- tary resources rather than primary learning tools, with continuous updates and proper training for both teachers and students in their appropriate use. For example, the following are students' suggestions: "*Some useful measures are the adoption of strict policies for the pro- tection of data, continuous renewal of the information and sources of the systems and appropriate training of teachers for their correct use during lessons*"; "*These barriers could be reduced by reviewing the results and comparing them with published studies. Also, for the comprehension problem we could provide more prompts with more specific information we are looking for*".

6. Discussion and Implications

While earlier studies have explored GenAI tools to support students' collaboration (e.g., assigning members to teams, developing assignments for teams, making recommen- dations to teams, evaluating teams' work), they have not explored how students actually collaborate among themselves while interacting with GenAI tools. This study investigated five different ways of students collaborating among themselves (collaborative modes) while interacting with GenAI tools to implement their team projects. Thirty students used these five collaborative modes while interacting with *ChatGPT*, *Gemini*, and *Copilot* to develop their IoT projects. Then, they presented their projects in class and answered a survey. The following paragraphs discuss the students' uses, preferences, challenges, perceptions, and expectations regarding the different collaboration modes as well as the different GenAI tools.

It was found that half of the students and teams used all five collaborative modes. The fact that most teams used multiple collaborative modes implies a preference for diversified collaborative modes, which may enhance learning outcomes and performance. The high us- age rates of specific collaborative modes, particularly *Collaborative Modes #2* (team-oriented, 86.7%), *#4* (team to member, 83.3%), and *#5* (independently/cooperatively, 80%), may be attributed to the perceived convenience, ease of use, accessibility, practicality, effectiveness, or engagement levels. The variation in collaborative mode adoption across teams highlights the differences in team dynamics, resource availability, time constraints, personality, or acceptance of specific modes. The fact that *Collaborative Mode #5* was the only method by the team that relied on a single collaborative mode suggests that this method might be particu- larly versatile, effective, or easy to adopt. In addition, *Collaborative Mode #2* (60% agreeing or strongly agreeing) was the most preferred, followed by *Collaborative Modes #5* (53.3% agreeing or strongly agreeing) and *#4* (46.6% agreeing or strongly agreeing). The relatively high standard deviations suggest some variability in individual preferences. Students identified the following criteria for selecting collaborative modes: speed, effectiveness, collective thinking, knowledge exchange, and autonomy, revealing a desire for balance between individual flexibility and team cohesion. For instance, students appreciated the autonomy in *Mode #5*, where individual exploration was followed by collaborative refine- ment, but they also valued the real-time team decision making in *Mode #2*. However, the challenges they faced, such as maintaining consistency in prompts and tracking progress, indicate the need for better tools and frameworks to support collaborative GenAI use. The results imply that the current GenAI tools lack features tailored for team collaboration, such as shared discussion spaces and organized shared histories of prompts and responses. This gap limits the potential for seamless teamwork and knowledge integration. These results are significant for educators and instructional designers, as they highlight the importance of integrating multiple preferred collaborative modes into the curricula to maximize student flexibility, engagement, and learning outcomes. Also, these findings are important because they underscore the growing role of GenAI in collaborative learning, emphasizing the need for tools that align with users' workflows and cognitive processes. AI developers can create GenAI tools with built-in features for team interaction, such as shared workspaces and progress tracking. Further investigation could further examine why students favored certain collaborative modes, potentially refining the teaching approaches and optimizing instructional design for better educational experiences.

Also, the results highlight the importance of collaborative decision making in student projects. While initial disagreements were common, students were ultimately able to reach consensus through discussion and argumentation. On average, students initially disagreed 24% of the time but eventually reached consensus. Although there were varying levels of conflict within teams, eventually, students were capable of negotiating, resolving conflicts, and finding common ground. The fact that most students (65.5%) initially disagreed on 20% of the issues suggests that some level of conflict is a natural part of decision making in collaborative projects. Educators can use these insights to design team-based learning activities that enhance students' ability to engage in productive discussions. Further investigation could examine why some teams faced more disagreement and how discussion quality influenced the outcomes.

In addition, the results show that students strongly believed they learned a significant amount about their project's topic during its implementation (40% agreeing, 60% strongly agreeing). However, the statistical analysis suggests that students' perceptions of learn- ing did not necessarily translate into higher project grades. It is possible that students overestimated their learning due to initial low knowledge levels or that the grading cri- teria did not fully align with the learning outcomes they valued. Students also believed their team partners learned a lot (53.3% agreeing, 43.3% strongly agreeing), reinforcing the collaborative nature of the learning process. The statistically significant association between their own learning perceptions and their perceptions of their teammates' learning suggests a shared sense of accomplishment and mutual reinforcement within teams. This means that when students feel confident about their own learning, they are more likely to assume that their peers had a similar experience. This underlines the collaborative nature of project-based learning, where students likely influence and support each other's under- standing. The results also reveal a comparatively lower perception of learning from other teams' presentations. This could be due to differences in presentation quality, relevance, audience engagement, or cognitive overload from watching multiple topics. It also implies that while peer presentations are valuable, they may not be as engaging and effective as hands-on project implementation. Enhancing the effectiveness of team presentations, through reflective practices, discussions, and peer feedback, could improve peer learning. Furthermore, the results reveal a strong preference among students for face-to-face communication and collaboration, complemented by digital tools when in-person interac- tion is not feasible. This preference is likely due to the immediacy, efficiency, and richer interpersonal dynamics that physical meetings offer. However, digital tools like *Zoom*, *Google Meet*, *Viber*, and *Google Drive* played a crucial role in maintaining communication during holidays or when scheduling conflicts arose. Similarly, Fischer et al. (2024) found videoconferencing to be effective for information exchange. Also, asynchronous communi- cation enabled students to reflect on their errors and develop more ideas than synchronous communication (Barrett et al., 2021). The results showed that students combined multiple digital tools, such as *Viber* for instant communication and *Google Drive* for file sharing, to effectively implement their team project. However, they also encountered challenges, such as poor internet connectivity and tool limitations.

These findings are important because they provide insights into how students balance digital and physical collaboration, em- phasizing the need for flexibility and adaptability in communication strategies. Educators can be informed by these results and design hybrid activities that combine the strengths of in-person and online communication and collaboration.

While students frequently employed *ChatGPT*, *Gemini*, and *Copilot* for basic informa- tion retrieval and content creation, their prompts remained largely simple, focusing on definitions, examples, and descriptions rather than engaging in deeper critical thinking or analytical tasks. Similarly, Luther et al. (2024) observed that people mostly asked content-related prompts for data, facts, and information. This suggests a reliance on GenAI as a quick-fix solution for knowledge acquisition rather than as a tool for fostering higher-order cognitive skills. The absence of advanced prompts, such as "why does. . .?", "evaluate. . .", or "critique. . .", indicates a missed opportunity to exploit GenAI for develop- ing higher-order cognitive skills like analysis, synthesis, and evaluation. Furthermore, the lack of prompts for text refinement, summarization, or diagram design implies a limited understanding of the tools' full potential. These results may be due to a lack of train- ing in effective GenAI usage, a focus on saving time over depth, or an over-reliance on surface-level learning strategies. Therefore, educators must integrate GenAI literacy into the curricula, teaching students to use these tools critically and creatively. Developers could design interfaces that encourage deeper engagement (e.g., by helping users ask more advanced and complex questions). These results are important because they highlight a gap between the potential of GenAI and its current application, underscoring the need for using these tools to enhance deep learning and not superficial learning.

The survey results provide a comprehensive understanding of students' perceptions of *ChatGPT*, *Gemini*, and *Copilot*, presenting their strengths, weaknesses, opportunities, and risks. Students excessively appreciated GenAI tools for their ability to deliver quick, clear, concise, comprehensive, and structured responses, to explain complex concepts, and to save time. Similarly, previous studies confirm the tools' quick responses (Montenegro-Rueda et al., 2023; Singh et al., 2023), complex concept explanations (Crompton & Burke, 2024; Montenegro-Rueda et al., 2023), and time-saving potential (Kakhki et al., 2024; Kasneci et al., 2023). *Gemini* and *Copilot* are particularly valued for their unique capabilities, such as image analysis, table handling, and providing real references. GenAI tools may enhance learning and productivity by acting as personal tutors, research assistants, and content creators. Students recognized the tools' ability to spark curiosity, guide research, and personalize learning, but they also emphasized the importance of using these tools as supplementary aids rather than primary sources. Likewise, prior research argues for the tools' ability to support personalized learning (Crompton & Burke, 2024; Dwivedi et al., 2023; Kakhki et al., 2024; Montenegro-Rueda et al., 2023), writing reports, essays, and scientific articles (Crompton & Burke, 2024; Singh et al., 2023).

However, there were concerns regarding accuracy, reliability, misinformation, and outdated information, particularly with *ChatGPT*'s lack of source citations and references, students' over-dependence, reduced critical thinking, and data privacy. Similarly, previous studies confirm the tools' possible inaccurate responses (Crompton & Burke, 2024; Das & Madhusudan, 2024; Dwivedi et al., 2023; Singh et al., 2023), misinformation (Crompton & Burke, 2024; Dwivedi et al., 2023), over-dependence risks (Kasneci et al., 2023; Luther et al., 2024; Singh et al., 2023), and data privacy risks (Crompton & Burke, 2024; Dwivedi et al., 2023; Luther et al., 2024; Montenegro-Rueda et al., 2023). However, previous findings regarding critical thinking are contradictory. Some studies argued that the tools may reduce students' critical thinking (Alnaim, 2024; Kasneci et al., 2023); others claimed that using *ChatGPT* responsibly can promote critical thinking (Suriano et al., 2025). Therefore, there is a need for responsible usage, critical thinking, proper training, and continuous updates to the tools' knowledge bases. While GenAI tools offer transformative potential, their effectiveness depends on how they are integrated into educational and professional contexts.

These results are important because they provide actionable insights for educators, policymakers, and AI developers. Educators can use these findings to design curricula that teach students how to use GenAI tools critically and ethically, fostering skills like fact checking, source evaluation, and independent thinking. Policymakers can develop guidelines to ensure equitable access to advanced GenAI tools while addressing data privacy and misinformation risks. Developers, on the other hand, can focus on improving the tools' accuracy, source attribution, and user interfaces, making them more reliable and accessible for educational purposes.

7. Conclusions, Limitations, and Future Research

This study provided empirical evidence on students' uses and preferences for different collaborative modes when working with GenAI tools in a team project setting. It also explored the criteria they used to select a collaborative mode, their preferred collaborative mode, the challenges they faced, and their suggestions for improving collaborative GenAI use. Thirty (30) postgraduate students formed teams of three members, who collaboratively developed their team projects regarding specific internet of things (IoT) application areas. Members of each team collaborated among themselves using five different collaborative modes while interacting with the free version of *ChatGPT*, as well as *Google Gemini* and *MS Copilot* (which have real-time internet access), in order to develop their team projects.

Regarding RQ1, half of all students and all teams used all five collaborative modes, while only one team used a single *Collaborative Mode #5*. Students mostly liked and preferred *Collaborative Mode #2*, followed by *Collaborative Mode #4* and *Collaborative Mode #5*. Students mostly liked *Collaborative Mode #2*, since it saved them time and enabled team cohesion and a collective way of thinking. The most preferred communication method was face to face, followed by a combination of an instant communication tool together with a file-sharing tool. It is suggested that educators appropriately design the collaborative activities in their courses, enabling diverse and flexible modes of communication and collaboration.

During their project's implementation, students had to collaboratively make several decisions. On average, team members initially disagreed among themselves in 24% of the cases before they eventually came to a consensus. Students acknowledged that they and their peers learned a lot about the IoT application area of their project during the develop- ment of their project and through interaction with GenAI tools. They also confessed that they acquired a lot of knowledge about other IoT application areas from the presentations of their colleagues.

Regarding RQ2, most students pointed out that a major strength of GenAI tools is that they can give answers really fast. However, they were mainly worried about whether the answers from GenAI tools were correct, trustworthy, and current. Students thought that these GenAI tools can act like personal tutors that can assist them in school and work. For example, these tools can make complex subjects easier to understand by explaining them in simple ways and giving examples. However, they recommended using these tools with caution, especially in educational environments, where teachers need to make sure that students truly comprehend the content instead of just copying it. Otherwise, there is a danger of decreased critical thinking and over-reliance on pre-generated answers.

Students would like for GenAI tools to offer a shared discussion space for collaborative prompt asking, allowing all team members to view each other's prompts and the tool's responses. An organized discussion history accessible to all team members would help maintain continuity and track progress and development. This feature would significantly enhance users' collaborative efforts. Furthermore, they would like GenAI to understand the context and provide accurate and up-to-date responses.

More specifically, this study contributes to the understanding of how students collabo- ratively use GenAI tools by

- Identifying preferred collaborative modes: The study pinpoints which collaborative modes (e.g., specific strategies for team interaction with GenAI) are favored by stu- dents.
- Highlighting key criteria for collaborative mode selection: It presents the factors that students consider important when choosing a collaborative mode, such as speed, effectiveness, knowledge exchange, and individual autonomy.
- Providing the *Collaborative Preparation*, *Implementation*, *Revision (CoPIR)* methodology for students to collaboratively develop their projects with GenAI help.
- Revealing challenges and suggestions: The study documents the problems students encounter while collaborating with GenAI and their ideas for improvement, includ- ing the need for a shared discussion space and structured history tracking for team discussions, within GenAI tools.
- Assessing learning perceptions: It examines students' perceptions of their own learning and their team members' learning in relation to their project grades.
- Documenting tool usage: The study records the digital tools and platforms students use for communication and collaboration, along with their satisfaction levels.
- Identifying advantages and disadvantages: It summarizes the strengths (e.g., speed) and weaknesses (e.g.,

inaccuracies, outdatedness) of GenAI tools, as perceived by students.

- Exploring opportunities and obstacles: The research explores the possibilities (e.g., personalized learning, time saving) and potential barriers (passive learning, privacy) to using GenAI tools effectively in learning and work environments.

The results of this study can inform the design of future educational practices.

In conclusion, the present study provides unique insights into the innovative use of AI tools in collaborative learning settings, highlighting both opportunities and challenges. The utility of this study lies in its potential to inform pedagogical strategies, AI tool design, and institutional policies, ultimately fostering more meaningful and effective AI use in higher education. However, this study also has some limitations that need to be addressed in future research. Such limitations include the relatively small sample size, which restricts the generalizability of the results. Future research would investigate large and differential samples, including students in various countries, universities, subjects, courses, academic levels, or even different users of GenAI tools in other sectors and industries (e.g., medicine, marketing, business). In addition, this study mainly uses students' perceptions and not data from students' actual usage of GenAI tools. Future research may employ available measurements using learning analytics, electroencephalogram, eye tracking, etc., to explore some of the issues examined by this study. Furthermore, this study investigated students during a particular semester. Future research may design long-term studies to investigate any long-term effects of students collaboratively using GenAI tools. The primary aim of this study was to investigate the collaborative use of popular GenAI chatbots. Future research may further examine other GenAI tools that can generate not only text but also image, audio, and/or video for various society and business sectors. For example, future research may explore the efforts of a team to collaboratively design a song, a movie, a building, a bridge, an engine, a piece of clothing or furniture, etc.

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Appendix A

Open-Ended Questions:

(1) *Collaboration Among Team Members while Working with GenAI Tools:*

What did you like most (e.g., ease of organization and implementation, better results, speed of obtaining results) about each method of collaboration with the AI tool that you used? What problems did you encounter in each method of collaboration with the AI tool, and what would you change to improve it?

(2) *Communication Among Team Members:*

How did you communicate as a team (e.g., via phone, email, Facebook, Messenger, Google Drive, Google Meet, Zoom, Skype, Padlet)? What did you like most about these ways of communication? What problems did you encounter in your communication and collaboration, and what would you change to improve them?

(3) *Advantages/Capabilities/Strengths of GenAI Tools:*

What did you like most about the AI tool? What were the strengths (abilities) of the AI tool in helping you learn?

(4) *Weaknesses/Limitations/Shortcomings of GenAI Tools:*

What did you not like about the AI tool? Which functions (abilities) of the AI tool need improvement?

(5) *Opportunities and Suggestions for Using GenAI Tools for Learning and Work:*

What opportunities for learning and work can the AI tool offer you? How could you use the AI tool for learning and work? What suggestions do you have for the use of the AI tool in education?

(6) *Obstacles and Risk Mitigation when Using GenAI Tools for Learning and Work:*

What would prevent you from using the AI tool for learning and work? What risks might there be to using the AI tool in learning and work? How could the obstacles and risks be reduced?

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