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Student Opinions on the Use of AI Tools in the Analysis and Management of Production Systems Course

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To my mom and dad,

Leaving Iran for Italy was the hardest and proudest thing I've ever done. The distance was never in kilometers, but in missing you. Even on the days we couldn't call, I still felt you with me. You gave me the courage to leave, and I was never truly alone.

This thesis is yours as much as it is mine.
I love you, and I carry you with me always.

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This thesis marks the end of an important chapter in my life, and I will always be grateful to everyone who helped me reach this milestone.

Abstract

Artificial intelligence (AI) tools have become common in higher education, and many students now use them as part of their daily learning. Although these tools are widely available, there is still limited understanding of how they are used in specific engineering courses and how students perceive their advantages and limitations. This thesis investigates the use of AI tools in the *Analysis and Management of Production Systems (AMPS)* course at Politecnico di Torino.

The research follows the Technology Acceptance Model (TAM), which examines four key dimensions of AI adoption: Perceived Ease of Use, Perceived Usefulness, Behavioral Intention to Use, and Perceived Challenges and Limitations. Data were collected through an online questionnaire completed by 52 students who attended the AMPS course between the academic years 2022–2023 and 2024–2025. The questionnaire included both Likert-scale and open-ended questions, allowing the study to combine quantitative results with students' personal experiences.

The results show that AI tools have become a regular part of students' study routines, with 90.4% of respondents reporting that they used at least one AI tool during the course. ChatGPT was by far the most frequently used tool. Students mainly used AI to understand difficult concepts, review course material, prepare for exams, and receive guidance when solving exercises. Most respondents found AI tools easy to use and helpful for supporting their learning. Students also recognised their limitations. Many reported that AI tools often produced inaccurate answers for numerical and analytical problems, provided explanations that were too general for course-specific topics, and did not always follow the methods taught during lectures. As a result, most students checked AI-generated answers against lecture notes, textbooks, or other reliable academic sources before using them.

The findings suggest that students view AI as a valuable learning support rather than a replacement for traditional study methods. They use these tools selectively, making use of their strengths while remaining aware of their limitations. The results also suggest that course-specific AI tools could better support students by reflecting the teaching methods, learning objectives, and content of the AMPS course.

Contents

Abstract

1 Introduction 1

2 Theoretical Background 3
2.1 AI in higher education . . . 3
2.2 Generative AI Tools in Learning . . . 5
2.2.1 Concept and Architecture of Generative AI . . . 5
2.2.2 ChatGPT as a Learning Tool . . . 6
2.2.3 Other Generative AI Tools and Their Roles in Learning Contexts . 7
2.3 Impact of Generative AI on Student Learning . . . 9
2.4 Technology Acceptance Model (TAM) . . . 9
2.5 Literature Search Strategy . . . 10
2.6 State of the Art . . . 10

3 Methodology 15
3.1 Questionnaire Design . . . 15
3.2 Data Collection . . . 17

4 Survey Results 18
4.1 Sample Description . . . 18
4.2 Students' Use of AI Tools . . . 20
4.2.1 AI Usage by Gender and Academic Year . . . 21
4.3 Descriptive Statistics of Survey Responses . . . 22
4.3.1 Perceived Ease of Use . . . 23
4.3.2 Perceived Usefulness . . . 24
4.3.3 Behavioral Intention to Use . . . 25
4.3.4 Perceived Challenges and Limitations . . . 26
4.4 Analysis of Open-Ended Questions . . . 28
4.5 Chapter Summary . . . 33

5 Analysis and Findings 34
5.1 Introduction . . . 34
5.2 Approach to the Analysis of Survey Responses . . . 34
5.3 Do Different AI Tools Influence Students' Perceptions? . . . 35

5.4 Do Male and Female Students Answer Similarly? . . . 36
5.5 Do Different Age Groups and Academic Years Have Similar Opinions? . . . 36
5.5.1 Age Group . . . 36
5.5.2 Academic Year of AMPS Attendance . . . 38
5.6 Do Students Who Use AI Every Day Have More Positive Opinions? . . . 38
5.7 Checking the Patterns Against the Open-Ended Answers . . . 39
5.8 Summary of Main Findings . . . 41
5.9 Comparison with Previous Literature . . . 41
5.10 Limitations of the Study . . . 43
5.11 Chapter Summary . . . 44

6 Conclusion and Future Work 45
6.1 Conclusion . . . 45
6.2 Future Work . . . 46

Bibliography 47

A Questionnaire 51

List of Figures

2.1 Hierarchical relationship between artificial intelligence, machine learning, deep learning, and generative AI. 5
2.2 Interaction process between students and ChatGPT in learning contexts . 6
2.3 Roles of AI Tools in Learning 7

4.1 Distribution of Respondents by Gender and Age Group ($n = 52$) 19
4.2 Distribution of Respondents by Academic Year of AMPS Attendance ($n = 52$) 20
4.3 AI Tools Used by Respondents ($n = 52$) 20
4.4 Frequency of AI Tool Use Among Respondents ($n = 52$) 21
4.5 AI Tool Usage by Gender ($n = 52$) 22
4.6 Perceived Ease of Use — Response Distribution (n = 52) 24
4.7 Perceived Usefulness — Response Distribution (n = 52) 25
4.8 Behavioral Intention to Use — Response Distribution (n = 52) 26
4.9 Perceived Challenges and Limitations — Response Distribution (n = 52) . 27
4.10 Student Interest in a Course-Specific AI Tool for AMPS (n = 48) 32

5.1 Average Scores by AI Tool Used (n = 52) 35
5.2 Average Scores by Gender (n = 52) 37
5.3 Average Scores by Age Group (n = 52) 37
5.4 Average Scores by Frequency of AI Tool Use ($n = 52$) 39

List of Tables

2.1 Comparison of Generative AI Tools in Learning Contexts 8
2.2 Studies Included in the Literature Review 11

4.1 Demographic Profile of Respondents ($n = 52$) 19
4.2 AI Tool Usage by Gender ($n = 52$) 21
4.3 AI Tool Usage by Academic Year ($n = 52$) 22
4.4 Descriptive Statistics for All Likert Scale Items (SD=Strongly Disagree, D=Disagree, N=Neutral, A=Agree, SA=Strongly Agree) ($n = 52$) 23
4.5 Summary of Advantages and Disadvantages Identified from Open-Ended Responses 29

5.1 Average Scores by AI Tool Used (n = 52) 35
5.2 Average Scores by Gender (n = 52) 36
5.3 Average Scores by Age Group (n = 52) 37
5.4 Average Scores by Academic Year of AMPS Attendance (n = 52) 38
5.5 Average Scores by Frequency of AI Tool Use ($n = 52$) 38
5.6 Weakness Themes Compared with the Challenges Score ($n = 52$) 40
5.7 Strength Themes Compared with the Usefulness Score ($n = 52$) 40
5.8 Interest in a Dedicated Chatbot Compared with Challenges and Usefulness Scores ($n = 52$) 41

Acronym List

AI	Artificial Intelligence
GenAI	Generative Artificial Intelligence
LLM	Large Language Model
NLP	Natural Language Processing
GPT	Generative Pre-trained Transformer
TAM	Technology Acceptance Model
AMPS	Analysis and Management of Production Systems
PEOU	Perceived Ease of Use
PU	Perceived Usefulness
BI	Behavioral Intention to Use
UTAUT	Unified Theory of Acceptance and Use of Technology
RAG	Retrieval-Augmented Generation
SD	Strongly Disagree (survey scale) / Standard Deviation (results table)
D	Disagree
N	Neutral
A	Agree
SA	Strongly Agree
n	Number of respondents (sample size)

Glossary

Artificial Intelligence (AI): Technology that lets a computer do things that normally need human thinking, like understanding text or answering questions.

Generative AI (GenAI): A type of AI that can create new content, such as text or images, instead of just finding information that already exists.

Large Language Model (LLM): A computer model trained on huge amounts of text. It learns patterns in language so it can understand questions and write answers.

ChatGPT: An AI chatbot made by OpenAI. In this study, it was the AI tool students used the most.

Google Gemini: An AI tool made by Google. Students in this study mainly used it to search for information and check facts.

Claude: An AI assistant made by Anthropic. Students said it was useful for organizing ideas and writing.

Microsoft Copilot: An AI tool made by Microsoft. Students used it mostly for coding and technical tasks.

Technology Acceptance Model (TAM): A theory that explains why people choose to use, or not use, a new technology. It says the two main reasons are how useful and how easy to use people think it is.

Perceived Usefulness (PU): How much a student feels that an AI tool really helps them, for example with understanding a topic or finishing an exercise.

Perceived Ease of Use (PEOU): How easy or difficult a student feels it is to use an AI tool.

Behavioral Intention to Use (BI): Whether a student plans to keep using an AI tool later, or would tell other students to use it.

Perceived Challenges and Limitations: The problems students noticed when using AI tools, such as wrong answers or explanations that were too general.

Likert Scale: A type of question used in surveys. People choose an answer on a scale, for example from "Strongly Disagree" to "Strongly Agree."

Cross-Sectional Survey: A study that collects data from people at one point in time, instead of following the same people over months or years.

Prompt: The question or instruction a person types into an AI tool to get an answer.

Hallucination: When an AI tool gives an answer that sounds correct but is actually wrong or made up. One student in this study used this exact word to describe the problem.

Scaffolding: In education, this means giving a student temporary help so that, later on, they can solve similar problems by themselves.

Natural Language Processing (NLP): The part of AI that lets a computer understand and use human language.

Deep Learning: A method inside machine learning that uses many layers of artificial "neurons" to find patterns in large amounts of data.

Transformer Architecture: The technical design used by GPT and other modern AI language models to read and generate text.

Chapter 1

Introduction

Artificial intelligence (AI) has become an essential part of higher education, having a strong influence on both the design and implementation of teaching and learning processes (Holmes et al., 2019). A wide range of AI-driven solutions, including intelligent tutoring systems, automated assessment tools, and adaptive learning environments, are increasingly used to support instructional activities and improve student engagement. In engineering education, these technologies allow for more interactive and dynamic learning experiences, helping students better understand complex concepts and improve their problem-solving skills (Kasneci et al., 2023). Furthermore, with the continuous development of digital technologies, AI-based applications are gradually being integrated into autonomous learning contexts, where students take a more active role in managing their own learning processes (Al-Zahrani, 2023).

In recent years, the fast development of generative AI tools, such as ChatGPT, Google Gemini, Claude, and Microsoft Copilot, has further accelerated the digital transformation of education. These tools are widely used by students to support academic activities through explanations, summaries, and help with various tasks. Existing studies show that generative AI technologies can make it easier to understand complex topics, improve the organisation of learning materials, and increase task efficiency (Kasneci et al., 2023). As a result, students increasingly see these tools as valuable resources for self-directed learning, where having quick access to information plays an important role in academic performance (Chan, 2023).

Despite these advantages, several concerns remain. AI-generated outputs may sometimes be inaccurate, incomplete, or misleading, which requires careful evaluation by users (Kasneci et al., 2023; Al-Zahrani, 2023). Moreover, relying too much on these tools may negatively affect the development of critical thinking and analytical skills, which are essential in higher education.

In engineering contexts, where students need to work with analytical models and solve real-world problems, the role of AI becomes particularly important. The course Analysis and Management of Production Systems at Politecnico di Torino focuses on the analysis and improvement of industrial production systems using methods such as process mapping and performance evaluation. This course combines theoretical knowledge with practical applications, requiring students to apply analytical techniques to real-world scenarios. In

this context, AI-based tools can provide meaningful support by helping students analyse models and explore alternative decision-making strategies.

Although the adoption of generative AI tools in higher education is increasing quickly, their impact on students' analytical reasoning is still unclear, particularly in engineering disciplines where a deep understanding is required. Within the AMPS course at Politecnico di Torino, little research has been done on how these technologies influence students' learning experiences. Therefore, this study aims to address this gap by looking at students' use of AI tools, their perceived usefulness and ease of use, and the challenges they faced during their use.

To achieve these objectives, the Technology Acceptance Model (TAM) is used as the theoretical framework. TAM is widely used to analyse the acceptance of technological innovations, and it identifies perceived usefulness and perceived ease of use as the main factors that determine users' behavioral intention. Perceived usefulness refers to the extent to which a technology improves user performance, while perceived ease of use reflects how simple and effortless the technology is considered to use.

Based on this framework, the study addresses the following research questions:

- How do students use AI tools for learning purposes in the Analysis and Management of Production Systems course at Politecnico di Torino?
- What is the students' perception of the usefulness of AI tools in supporting their understanding of course topics?
- To what extent do students perceive AI tools as easy to use?
- What challenges do students face when using AI tools in their learning process?

The remainder of this thesis is organized as follows. Chapter 2 reviews the relevant literature on artificial intelligence in higher education and the Technology Acceptance Model (TAM). Chapter 3 describes the research methodology, including the questionnaire design and data collection procedures. Chapter 4 presents the survey results and descriptive analysis of the collected data. Chapter 5 analyses the findings in relation to the research questions and existing literature. Finally, Chapter 6 presents the conclusions of the study and suggests directions for future work.

Chapter 2

Theoretical Background

2.1 AI in higher education

Artificial Intelligence (AI), which is considered one of the most important technological developments of the 21st century, has a growing influence on many sectors, including education. While its recent popularity has increased with generative models, the origins of AI go back several decades. The term "Artificial Intelligence," which was first introduced by John McCarthy during the Dartmouth Conference, marked the beginning of AI as a formal academic field (Russell & Norvig, 2021). Earlier conceptual work by Alan Turing, who suggested the idea that machines could simulate human intelligence, also contributed to this foundation (Turing, 1950). AI generally refers to systems that are able to perform tasks that normally require human cognitive functions, such as reasoning, learning, and language processing (Russell & Norvig, 2021).

The evolution of AI, defined by a non-linear path, has gone through many phases shaped by technological and methodological changes. Early AI systems, which were developed between the 1950s and 1970s, were mainly based on symbolic reasoning and rule-based logic, often called expert systems. These systems tried to formalize human knowledge into fixed principles, but they were limited in their ability to deal with new or uncertain situations (Zawacki-Richter et al., 2019). From the 1980s onwards, AI shifted toward machine learning, which introduced data-driven approaches that allowed systems to improve through experience. This change represented a key turning point when AI moved from rigid programming to more adaptive learning systems.

In the following decades, especially during the 2000s and 2010s, improvements in computing power and access to large amounts of data helped bring about major developments in deep learning techniques. Deep neural networks have achieved remarkable success in areas like image recognition and natural language processing (Goodfellow et al., 2016). The most recent innovation in AI is the arrival of generative AI, which can be considered the new generation of AI. Generative AI can produce text, images, code, and other creative material, allowing AI to interactively help generate knowledge (Dwivedi et al., 2023).

Moreover, this trend has even reached higher education, with the adoption of AI becoming more common in teaching and learning activities within university institutions. Technologies such as adaptive learning software, automated assessment tools, and intelligent tutoring systems help create personalized responses for learners, thus supporting the shift

from teacher-centered approaches to more student-focused settings (Holmes et al., 2019; Zawacki-Richter et al., 2019).

From the student perspective, AI tools, which are becoming a regular part of academic practice, provide immediate explanations, help students understand complex concepts, and support self-learning. This is especially important in higher education, where students are expected to manage large amounts of information and apply knowledge in problem-solving contexts. However, the use of AI also raises important concerns, such as over-reliance on generated outputs, which can negatively affect critical thinking skills (Kasneci et al., 2023).

In technical and engineering fields, such as the course Analysis and Management of Production Systems at Politecnico di Torino, the use of AI technologies plays a very important role. This kind of subject requires critical thinking and problem-solving skills, and AI technologies can therefore be of great help in activities such as data analysis, problem structuring, and concept building, among others. However, their use should be carefully managed to make sure that students remain actively engaged in the learning process. Since AI is increasingly present in students' studies, there is a need to understand how these technologies are used and perceived within specific learning situations, which is the objective of this research paper.

2.2 Generative AI Tools in Learning

2.2.1 Concept and Architecture of Generative AI

GenAI, which represents the most advanced level of artificial intelligence technology, can be described by its ability to create new information rather than analyzing or categorizing information that already exists. It is worth noting that this feature of the technology has developed due to continued advances in the field. To have a better understanding of the subject, the relationship among artificial intelligence, machine learning, deep learning, and GenAI, as well as the way they are structured hierarchically, should be considered. Figure 2.1 provides more information in this respect.

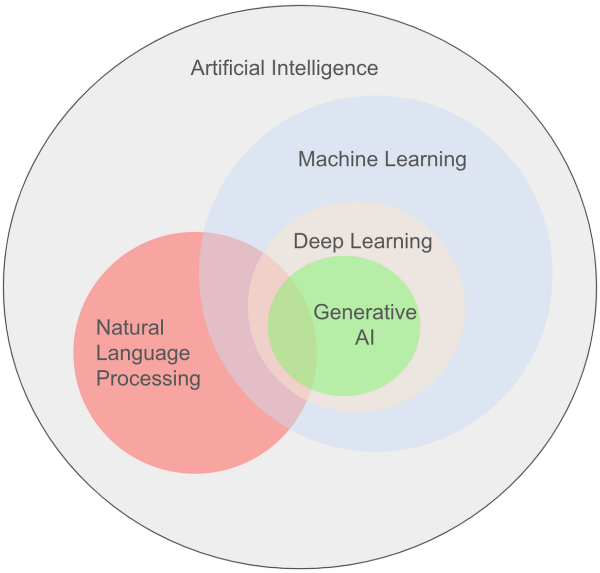


Figure 2.1: Hierarchical relationship between artificial intelligence, machine learning, deep learning, and generative AI.

As shown in Figure 2.1, artificial intelligence forms the largest category, within which machine learning forms a smaller subcategory that allows the system to learn from data. The subcategory of deep learning, which falls under machine learning, involves neural networks that handle large-scale information processing. In this arrangement, generative AI forms an important component, since it uses deep learning techniques to produce unique outputs.

Moreover, Figure 2.1 shows the importance of Natural Language Processing (NLP), which falls within the scope of both machine learning and deep learning. Because of NLP's ability, systems can process and generate language, which makes communication between generative AI models and humans more intuitive and natural.

Unlike conventional AI techniques, which use predefined rules, generative AI uses deep learning methods to analyse complex patterns from large data sets and produce unique results. These systems work using the LLM concept, which involves transformer models that identify statistical correlations among linguistic data (Dwivedi et al., 2023). This

allows generative AI to generate natural responses rather than simply extracting relevant information from the available data.

From an educational perspective, this architecture highlights an important distinction: while conventional technologies generally support passive forms of learning, these new AI systems are designed to interact through natural language communication. This allows for a more conversational and interactive learning experience, where learners can actively engage with the technology rather than simply receive information.

2.2.2 ChatGPT as a Learning Tool

ChatGPT, which is created by OpenAI, represents one of the best examples of generative AI in higher education. ChatGPT is seen as an important tool in academic contexts because it represents a new generation of systems that go beyond simple search tools. The GPT technology is based on the Generative Pre-trained Transformer architecture and has been upgraded from GPT-3.5 to GPT-4 (OpenAI, 2023).

From a theoretical point of view, ChatGPT is an interface that helps create contact between the student and information in a two-way communication setting. Unlike conventional learning materials that only offer one way of communicating and getting information in a static form, ChatGPT gives students the opportunity for a dynamic exchange where they get answers to their questions and build understanding through communication.

The interaction process between the student and ChatGPT, as shown in Figure 2.2, is cyclic and helps the student learn through improvement and reflection.

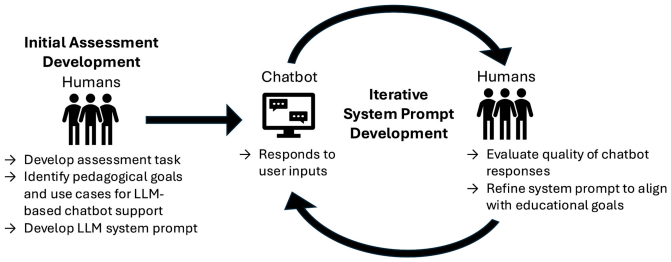


Figure 2.2: Interaction process between students and ChatGPT in learning contexts

As shown in Figure 2.2, the cycle starts with an initial prompt from the learner, who formulates a query or learning goal. Once a response is received, the learner evaluates the output, considers how relevant it is, and adjusts the prompt if needed. This cycle allows learners to take an active part in the learning process instead of being passive recipients of knowledge.

ChatGPT supports learning by functioning as a scaffolding tool that helps learners divide a problem into smaller components. For example, in subjects like analysis and management of production systems, learners have to analyze and evaluate the performance of systems. Instead of just providing solutions, ChatGPT helps learners understand the thought process involved in reaching a solution.

Moreover, ChatGPT allows students to organise their thoughts by formulating questions based on their ideas. The answers provided by ChatGPT are usually quick and well-organised, helping students develop their reasoning skills and improve their clarity. As

a result, cognitive activities become more visible, and this process can reduce cognitive effort while still supporting conceptual understanding (Kasneci et al., 2023).

However, how effective ChatGPT is for learning depends a lot on how it is used. While the system can generate coherent and well-structured responses, it does not truly understand the content and may sometimes produce inaccurate or misleading results. For this reason, students should critically evaluate its outputs rather than accepting them without reflection. When used actively and thoughtfully, ChatGPT does not replace learning; instead, it supports it by encouraging exploration, reflection, and deeper understanding.

2.2.3 Other Generative AI Tools and Their Roles in Learning Contexts

After the rapid rise of ChatGPT in late 2022, several other generative AI tools appeared, further changing the way students interact with digital learning environments.

This expansion shows that generative AI is no longer limited to a single tool, but instead represents a broader ecosystem in which different systems support different aspects of learning. As shown in Figure 2.3, generative AI tools can be understood in terms of their functional roles within educational environments. Most of these platforms have been developed by large tech companies, reflecting the growing integration of artificial intelligence into education. For example, Google introduced Gemini as part of its broader AI ecosystem, Anthropic developed Claude with a focus on safer and more structured interactions, and Microsoft released Copilot, integrating AI into productivity and programming tools.

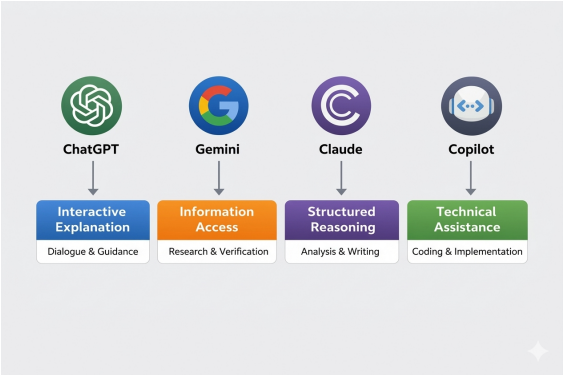


Figure 2.3: Roles of AI Tools in Learning

As shown in Figure 2.3, the roles of generative AI tools can be grouped into four main functions: interactive explanation, information access, structured reasoning, and technical assistance. These roles represent different forms of support and help explain how students interact with AI systems during learning.

More specifically, each of these tools can be linked to a specific function. ChatGPT provides an interactive way to explain things, helping students engage in a conversation to get a detailed answer to their question. Gemini is mainly focused on information retrieval, as it helps search for information and check its credibility. Claude is characterised by structured reasoning and logical coherence, and it can help with writing. Finally, Copilot

is able to assist with coding.

This classification suggests that these AI technologies are not substitute options but rather complements, since each of them is helpful at a certain point during learning. In reality, learners use several of these AI technologies at the same time, depending on their needs, which makes the whole process even more efficient. For instance, a learner may start with ChatGPT to clarify a particular concept, use Gemini to find more information, consult Claude to organise their thoughts, and put them into practice using Copilot.

Table 2.1 provides a comparative overview of the main characteristics and roles of these tools based on recent studies (Dwivedi et al., 2023; Kasneci et al., 2023; OpenAI, 2023).

Table 2.1: Comparison of Generative AI Tools in Learning Contexts

Feature	**Gemini**	**Copilot**	**ChatGPT**	**Claude**
Developer	Google	Microsoft	OpenAI	Anthropic
Model	Gemini	GPT-based	GPT-3.5/4	Claude
Capability	Multimodal (text, image, data)	Code generation	Text generation	Structured text
Strengths	Information retrieval and comparison	Coding and debugging support	Clear explanations and interaction	Structured reasoning and writing
Weaknesses	Limited reasoning	Limited outside coding tasks	Possible inaccuracies	Limited tool integration
Role	Information access	Technical support	Interactive explanation	Structured reasoning
Use	Search, compare, summarize	Write, debug, implement code	Explain, answer questions, guide step by step	Write, structure, organize ideas

Based on the information given in Table 2.1, each tool offers a different type of assistance. ChatGPT provides an interactive explanation service that allows students to learn through step-by-step processes. Gemini offers information access services to help users explore or verify content. Claude is useful for structured reasoning tasks that support writing and analysis skills, while Copilot helps with technical operations like coding.

To conclude, generative AI tools play different and complementary roles in learning environments, and they can support students' learning processes at multiple levels. These technologies help learners move from conceptual understanding to knowledge application, which is particularly important in engineering education. Learners, however, remain the key decision-makers, as they evaluate the relevance and quality of the responses generated by AI and can choose different tools depending on the learning situation or a particular concept.

2.3 Impact of Generative AI on Student Learning

The influence of AI-generated tools on students' learning process has become an important issue that needs to be addressed, especially because of how widely these tools are used in various learning institutions. Unlike other studies which focus on describing how the tools work, recent research tries to understand the influence they have on learning processes and outcomes.

There is some research indicating the usefulness of generative AI in education when these technologies are implemented properly. For example, experiments have shown that when used in academic tasks, ChatGPT contributes to the development of higher-level cognitive skills, including critical thinking, creativity, and reflection (Kung et al., 2023). Additionally, AI feedback can be useful since it helps students get quick and accurate suggestions on what needs to be improved during writing assignments; at the same time, AI tools can improve student engagement and motivation (Deng & Joshi, 2024). Finally, in technical subjects, AI tools like GitHub Copilot are useful for students while working on coding tasks, since they improve task performance and efficiency (Chen et al., 2025).

However, the literature suggests there are some issues connected with the use of these innovations that show their limitations in educational contexts. The first major problem is over-reliance on the technology, as learners could start depending on the answers provided by the AI system rather than working through the educational materials themselves. In this case, students do not engage in a meaningful learning process and, as a result, do not develop their critical thinking skills (Deng & Joshi, 2024). Furthermore, having access to technology like ChatGPT alone does not guarantee an improvement in learning performance, especially when it is used in a passive way. The problem of credibility of AI content should also be considered, since there might be inaccuracies in the content generated by these technologies (Kasneci et al., 2023).

Such results indicate that the use of generative AI by students will not necessarily have a positive or negative effect on their learning outcomes; rather, it depends on how these technologies are used. If learners participate in the process by asking questions to the AI system and analyzing the answers, they become more involved and learn better. Otherwise, they might learn less efficiently.

In summary, generative AI applications offer both opportunities and challenges and are reshaping the learning experience in higher education. The effectiveness of these tools is closely related to the balance between support and independence, which makes it important to know more about students' interaction with these technologies. This view, which considers both advantages and disadvantages, serves as the foundation for the next section, where the Technology Acceptance Model (TAM) will be used to examine students' attitudes and adoption of generative AI technology.

2.4 Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), introduced by Davis (1989), is one of the most widely used frameworks for explaining the adoption of new technologies. According to Davis (1989), users' acceptance of a system is mainly influenced by two key factors: perceived usefulness and perceived ease of use. Perceived usefulness refers to the extent to which a user believes that a system improves performance, while perceived ease of use

relates to how simple and effortless the system is to use. Together, these factors explain why individuals choose to adopt or reject a technology.

As digital technologies have become an essential part of university education, TAM has been widely used to analyse how students interact with technological systems (Davis, 1989). With the rise of generative AI tools such as ChatGPT, which support tasks like explanation, writing, and problem-solving, the model has become even more relevant for understanding students' engagement in academic contexts.

However, generative AI introduces specific characteristics that are not fully captured by the original TAM framework. While perceived usefulness and ease of use remain important, students' experiences with AI tools are also shaped by certain limitations, which may affect their willingness to rely on these systems. For example, AI tools may produce inaccurate responses, give overly general explanations, or require users to check information through external sources.

To take these aspects into account, this study extends TAM by including perceived challenges, which refer to the difficulties students face when using generative AI tools. These challenges include the generation of incorrect answers, explanations that are too general, and the need to validate AI-generated information, particularly in the AMPS course when doing analytical and problem-solving tasks.

2.5 Literature Search Strategy

Studies for this literature review were identified through a search on Google Scholar, conducted in two stages. The search initially began with broad terms such as AI in Higher Education, Impact of AI in Higher Education, Artificial Intelligence in Higher Education, Use of ChatGPT, Role of Artificial Intelligence, and Questionnaire-based studies, which returned around 100 papers. Particular attention was given to publications from 2022 to 2025, the period during which tools such as ChatGPT became widely used in academic contexts. These were screened by reviewing their titles, abstracts, and keywords to determine their relevance to the present study.

Since many of these initial results were only loosely related to the research focus, the search was refined using more specific terms, including Students' Use of AI, ChatGPT, Technology Acceptance Model (TAM), Technology Acceptance Model and ChatGPT, and UTAUT (Unified Theory of Acceptance and Use of Technology). This second search led to a closer, more careful review of the results, from which 30 studies were ultimately selected as directly relevant to the present research and included in the literature review.

A clear pattern emerged across these studies: TAM was by far the most commonly used framework for examining students' acceptance and use of AI tools. Given this, TAM was adopted as the theoretical framework for the present study.

2.6 State of the Art

These studies, summarised in Table 2.2, provide an overview of the literature used in this research.

Table 2.2: Studies Included in the Literature Review

Ref. No.	Title and Year	Main Topic / Focus	Cluster Name
1	Artificial Intelligence (AI) in Education: A Case Study on ChatGPT's Influence on Student Learning Behaviors (2024)	Examines how ChatGPT influences student engagement, motivation, and learning behaviors in higher education.	AI Tools in Higher Education and Course-Based Learning
2	Revolutionising Distance Learning: A Comparative Study of Learning Progress with AI-Driven Tutoring (2024)	Compares traditional and AI-supported distance learning, focusing on learning progress, motivation, and persistence.	AI Tools in Higher Education and Course-Based Learning
3	The Application of Generative Artificial Intelligence in the Teaching of Engineering Courses in Chinese Universities (2024)	Discusses the use of generative AI in engineering education, highlighting both opportunities and associated challenges.	AI Tools in Higher Education and Course-Based Learning
4	ChatGPT in Engineering Education: A Breakthrough or a Challenge? (2025)	Explores both the benefits and limitations of ChatGPT in engineering education, including ethical aspects and critical thinking.	Perceived Risks and Limitations
5	The Design and Implementation of an Educational Chatbot with Personalized Adaptive Learning Features for Project Management Training (2025)	Focuses on the design and implementation of an adaptive chatbot supporting personalized learning in project management education.	AI Tools in Higher Education and Course-Based Learning
6	Engineering Students' Use of Large Language Model Tools: An Empirical Study Based on a Survey of Students from 12 Universities (2025)	Investigates engineering students' use of large language model tools and their impact on learning efficiency and ethical awareness.	Perceived Usefulness, Perceived Ease of Use, and Behavioral Intention
7	Enhancing Educational Gamification through AI in Higher Education (2024)	Demonstrates how AI-based gamification can improve student motivation and engagement in higher education environments.	AI Tools in Higher Education and Course-Based Learning
8	Enhancing Python Learning with PyTutor: Efficacy of a ChatGPT-Based Intelligent Tutoring System in Programming Education (2024)	Evaluates a ChatGPT-based intelligent tutoring system and its impact on programming learning outcomes.	AI Tools in Higher Education and Course-Based Learning
9	Exploring the Broad Impact of AI Technologies on Student Engagement and Academic Performance in University Settings in Afghanistan (2024)	Examines the relationship between AI usage, student engagement, and academic performance in higher education.	Perceived Risks and Limitations
10	Exploring ChatGPT Utilization Among Master's Students in Higher Education (2024)	Investigates students' perceptions, usage patterns, and adoption of ChatGPT in higher education.	Acceptance of AI Technologies in Higher Education

Ref. No.	Title and Year	Main Topic / Focus	Cluster Name
11	Generative Artificial Intelligence in Higher Education: Exploring Ways of Harnessing Pedagogical Practices with the Assistance of ChatGPT (2024)	Discusses pedagogical opportunities and challenges associated with generative AI in higher education.	Acceptance of AI Technologies in Higher Education
12	Implementing Learning Principles with a Personal AI Tutor: A Case Study (2023)	Examines how AI tutors support personalized and adaptive learning processes.	AI Tools in Higher Education and Course-Based Learning
13	Performance of ChatGPT on USMLE: Potential for AI-Assisted Medical Education Using Large Language Models (2023)	Evaluates ChatGPT's reasoning capabilities and its potential role in AI-assisted medical education.	AI Tools in Higher Education and Course-Based Learning
14	Enhancing Programming Education with ChatGPT: A Case Study on Student Perceptions and Interactions in a Python Course (2024)	Investigates student perceptions and interactions with ChatGPT in programming education contexts.	Perceived Usefulness, Perceived Ease of Use, and Behavioral Intention
15	Role of Artificial Intelligence Tools in Enhancing Students' Educational Performance at Higher Levels (2023)	Explores the contribution of AI tools to academic performance and skill development in higher education.	Perceived Usefulness, Perceived Ease of Use, and Behavioral Intention
16	Subject-Specialized Chatbot in Higher Education as a Tutor for Autonomous Exam Preparation (2025)	Examines the use of subject-specific AI chatbots for autonomous exam preparation and learning support.	AI Tools in Higher Education and Course-Based Learning
17	The Effectiveness of Artificial Intelligence (AI) on Daily Educational Activities of Undergraduates in a Modern and Diversified University Environment (2024)	Investigates how AI tools support daily educational activities and student engagement.	Perceived Usefulness, Perceived Ease of Use, and Behavioral Intention
18	The Role and Impact of ChatGPT in Educational Practices: Insights from an Australian Higher Education Case Study (2024)	Provides qualitative insights into the role of ChatGPT in teaching and learning practices.	Perceived Risks and Limitations
19	Using GenAI in Education: The Case for Critical Thinking (2024)	Highlights the importance of critical thinking and AI literacy in AI-supported education.	Perceived Risks and Limitations
20	Enhancing Information Technology Governance in Universities: A Smart Chatbot System Based on ITIL (2024)	Describes an AI-based chatbot supporting academic and administrative processes in higher education institutions.	AI Tools in Higher Education and Course-Based Learning
21	AI-Based Chatbots Adoption Model for Higher-Education Institutions: A Hybrid PLS-SEM–Neural Network Modelling Approach (2022)	Develops and validates an adoption model for AI chatbots using PLS-SEM and neural network approaches.	Acceptance of AI Technologies in Higher Education

Ref. No.	Title and Year	Main Topic / Focus	Cluster Name
22	Artificial Intelligence Bringing Improvements to Adaptive Learning in Education: A Case Study (2024)	Examines how AI technologies enhance adaptive learning systems and improve student performance.	AI Tools in Higher Education and Course-Based Learning
23	Educational Technology in the University: A Comprehensive Look at the Role of a Professor and Artificial Intelligence (2024)	Investigates the role of AI in transforming teaching practices and the role of instructors in higher education.	Acceptance of AI Technologies in Higher Education
24	Exploration of Artificial Intelligence (AI) Application in Higher Education: A Research Study in Kolaka, Southeast Sulawesi (2024)	Explores perceptions and adoption of AI tools among educators and institutions.	Acceptance of AI Technologies in Higher Education
25	GPTutor: A Generative AI-Powered Intelligent Tutoring System to Support Interactive Learning with Knowledge-Grounded Question Answering (2024)	Describes a generative AI tutoring system supporting interactive and knowledge-grounded learning.	AI Tools in Higher Education and Course-Based Learning
26	Key Factors Influencing Preservice Chinese Teachers' Willingness for Implementing AI Applications in Higher Education (2025)	Identifies factors influencing teachers' willingness to adopt AI technologies in educational settings.	Acceptance of AI Technologies in Higher Education
27	Roles and Research Trends of Artificial Intelligence in Higher Education: A Systematic Review of the Top 50 Most-Cited Articles (2022)	Provides a systematic review of research trends and applications of AI in higher education.	Acceptance of AI Technologies in Higher Education
28	Configuring and Monitoring Students' Interactions with Generative AI Tools: Supporting Teacher Autonomy (2025)	Examines how instructors monitor and manage students' interactions with generative AI tools.	Perceived Risks and Limitations
29	Transforming Higher Education in the Era of AI Chat Tools: A Case Study (2024)	Explores institutional and educational transformations driven by AI chat tools.	Acceptance of AI Technologies in Higher Education
30	Tutor CoPilot: A Human–AI Approach for Scaling Real-Time Expertise (2025)	Presents a human–AI tutoring model designed to enhance learning support and real-time feedback.	AI Tools in Higher Education and Course-Based Learning

The analysis of the selected literature identified four main themes that represent the key research areas related to this topic.

The first cluster, AI tools in higher education and course-based learning, includes studies that look at the role of AI tools as integrated into learning environments and connected to course-based activities. As shown by Nguyen et al. (2024), Zhao et al. (2024), Khodadad (2025), Chen et al. (2025), Ma et al. (2024), and Sánchez-Vera (2025), AI tools can increase the efficiency of the learning process by providing explanations, adaptive support, and help with problem-solving tasks. Similarly, according to Yang et al. (2024), Lui et al. (2024), and Wang et al. (2025), the use of AI-based tutoring systems

increases interactivity and improves the teaching and learning process. However, most of the studies mentioned are carried out in general educational contexts and are not always limited to a specific course that requires analytical reasoning and problem-solving.

The second cluster involves the acceptance of AI technologies in higher education, focusing on how students and educators adopt AI tools based on theoretical frameworks such as the Technology Acceptance Model (TAM), extended TAM, and UTAUT. Studies such as Rahim et al. (2022), Jahani et al. (2024), Nikolopoulou (2024), and several recent survey-based studies show that acceptance depends on perceived usefulness and perceived ease of use, which shape users' attitudes toward AI tools. Moreover, factors such as trust, motivation, and prior experience are identified as important elements that influence the adoption of these technologies in academic contexts.

The third cluster, perceived usefulness, perceived ease of use, and behavioral intention, relates to the main dimensions examined in this study. As observed in studies by Li, Li, and Qiao (2025), Jahani et al. (2024), and other empirical works, students tend to use AI tools because they perceive them as useful for improving understanding, saving time, and completing academic tasks. Furthermore, ease of use and intuitive interaction are significant factors that influence behavioral intention, particularly for conversational AI systems and intelligent tutoring tools.

The fourth cluster, perceived risks and limitations, focuses on the potential challenges connected with the use of AI tools in higher education. As shown by studies such as Khodadad (2025), Sandu et al. (2024), Fazil et al. (2024), and other related research, these risks include over-reliance on AI-generated outputs, reduced development of critical thinking skills, issues related to accuracy, and concerns about academic integrity. These studies point out that the effectiveness of AI tools depends not only on their capabilities but also on how students use them and how much users critically evaluate the generated information.

Although previous studies provide valuable insights, there is still limited understanding of how students use and evaluate AI tools in specific courses that require analytical thinking and practical problem-solving. In the Analysis and Management of Production Systems course at Politecnico di Torino, where students apply analytical methods to real-world problems, the impact of AI tools on learning remains largely unexplored.

Therefore, this study aims to address this gap by looking at students' use of AI tools, their perceived usefulness and ease of use, and the challenges they experience in this course context. To address this objective, the questionnaire was designed based on an extended TAM framework, which was used to explore students' perceptions of AI tools, including both their benefits and limitations in the AMPS course.

Chapter 3

Methodology

3.1 Questionnaire Design

For the purpose of this research, the course "Analysis and Management of Production Systems" in the Master of Engineering and Management programme at Politecnico di Torino was chosen as the case study. This study uses a quantitative research design with a cross-sectional survey approach to collect data from respondents during a specific period. The questionnaire was developed systematically based on an extended TAM framework, instead of a set of randomly selected questions. This approach provided a clear theoretical framework to explore students' perceptions of AI tools, taking into account their advantages and disadvantages in the AMPS course.

The first section of the questionnaire focused on demographic and background information, including gender, age group, and the academic year during which students attended the AMPS course (2022–2023, 2023–2024, or 2024–2025). In addition, students were asked whether they had used AI tools such as ChatGPT, Google Gemini, Claude, or Microsoft Copilot during the AMPS course. The questionnaire also included an option for students who had not used any AI tools in the course. Students who used AI tools were further asked about how often they used them. This section provided a general overview of students' familiarity with AI technologies within the context of the AMPS course, how frequently AI tools were used during the course, the purposes for which they were used (e.g., understanding analytical concepts, solving exercises, exam preparation), and students' perceptions of the benefits and challenges connected to using these kinds of tools in the learning process.

The next sections of the survey, from 2 to 5, were organised around the main dimensions of the extended TAM framework used to guide the design of the questionnaire. A five-point Likert scale was used, ranging from (1 = Strongly disagree), (2 = Disagree), (3 = Neutral), (4 = Agree), and (5 = Strongly agree). The second section refers to "Perceived Ease of Use," which describes how easy and simple users consider a technology to be. This variable shows whether users feel comfortable using a system and can use it without difficulty or extra effort. This part included three questions:

- Q1: "The AI tool I used was easy to use."
- Q2: "I felt comfortable asking the AI tool questions about production system topics."

- Q3: “I could use the AI tool without additional assistance.”

The third component refers to "Perceived Usefulness," which measures the degree to which individuals see technology as able to improve their effectiveness or help them with their tasks. Within the field of education, this concept helps measure whether students perceive benefits from using AI technologies to understand lessons and solve problems. Four questions were used to measure this factor:

- Q1: “The AI tool helped clarify the difficult concepts of the course.”
- Q2: “The AI tool helped me solve problems and exercises of the course.”
- Q3: “The AI tool improved my understanding of exercises and assignments of the course.”
- Q4: “The AI tool helped me prepare for the exam of the course.”

The fourth part is about "Behavioral Intention to Use," which indicates users' intention to use the technology. In this case, this variable was used to find out whether the participants were willing to use AI technologies for their academic purposes again or not. This section consisted of three questions:

- Q1: “I intended to use the AI tool regularly in the AMPS course.”
- Q2: “I plan to continue using the AI tool for similar courses.”
- Q3: “I would recommend using the AI tool for the AMPS course to other students.”

The fifth variable is titled "Perceived Challenges and Limitations," which covers the challenges and limitations that may come up during the use of AI technologies. This variable allowed the study to look at the benefits of AI tools and the challenges students faced when using them, especially in terms of analytics and problem-solving capabilities. Four questions were asked under this variable.

- Q1: “The AI tool sometimes provided incorrect solutions for numerical or analytical problems.”
- Q2: “Answers from the AI tool were sometimes too general for detailed questions.”
- Q3: “I feel the need to verify the AI tool answers using lecture notes or textbooks.”
- Q4: “The AI tool do not work well for some specific AMPS problems.”

Finally, the sixth part of the survey included open-ended questions about students' experiences with AI tools in the AMPS course. Students were asked to describe how these tools supported their learning, identify possible drawbacks or limitations, and share their opinions about the usefulness of an AI chatbot designed specifically for the AMPS course. These questions provided additional qualitative insights beyond the closed-ended questions presented in the previous sections. The complete questionnaire used in this study is provided in Appendix A.

3.2 Data Collection

The data for this study were collected through an online questionnaire developed using Google Forms. The survey was distributed to students enrolled in the Analysis and Management of Production Systems (AMPS) course within the Master of Engineering and Management programme at Politecnico di Torino. The questionnaire was shared through the university academic portal and distributed by the course professor via email to approximately 400 students who had attended the course between the academic years 2022–2023 and 2024–2025.

The target population included both Italian and international students in the field of Management Engineering. In addition to the official university distribution channels, the survey link was also shared through academic student groups and social platforms such as LinkedIn and WhatsApp in order to increase participation and reach international students more effectively. To make sure the questionnaire was accessible to all participants, it was designed and distributed in English.

Participation in the survey was voluntary, and respondents were informed about the objectives of the research and their rights as participants before completing the questionnaire. Written consent was obtained from all respondents before participation. To protect respondents' anonymity and privacy, no personally identifiable information was collected, and all responses were stored anonymously and treated confidentially, for academic research purposes only.

The survey remained open from 12 April 2026 until 12 May 2026. During this period, responses were automatically collected and recorded through the Google Forms platform for later analysis.

Chapter 4

Survey Results

This chapter presents the results of the survey conducted among students who attended the Analysis and Management of Production Systems (AMPS) course at Politecnico di Torino. It starts with an overview of the respondents and their use of AI tools, followed by the presentation of the results for the main questionnaire constructs: Perceived Ease of Use, Perceived Usefulness, Behavioral Intention to Use, and Perceived Challenges and Limitations. The chapter also looks at the responses to the open-ended questions to provide additional insight into students' experiences with AI tools in the course.

4.1 Sample Description

After the students completed the survey, a total of 64 responses were initially collected. During the data-cleaning process, 11 responses from students attending the course in the academic year 2025–2026 were excluded, since these students had not yet taken the exam and could not properly answer all the questions. One additional response was removed due to an incorrect academic year entry. The final valid sample consisted of 52 responses,which formed the final sample for this study.

Table 4.1 and Figure 4.1 show the demographic profile of the respondents. The sample was almost equally divided between male (51.9%) and female (48.1%) students. The largest age group was 24–26 years old (40.4%), followed by students under 24 years old (30.8%), students aged 30 years or above (19.2%), and students aged 27–29 years (9.6%). Regarding the academic year of AMPS attendance, as shown in Figure 4.2, the majority of respondents (78.8%) attended the course during the 2024–2025 academic year, while 17.3% attended during 2023–2024 and 3.8% attended during 2022–2023.

Table 4.1: Demographic Profile of Respondents ($n = 52$)

Variable	Category	n (%)
Gender	Male	27 (51.9%)
	Female	25 (48.1%)
Age Group	Under 24	16 (30.8%)
	24–26	21 (40.4%)
	27–29	5 (9.6%)
	30 or above	10 (19.2%)
Academic Year	2022–2023	2 (3.8%)
	2023–2024	9 (17.3%)
	2024–2025	41 (78.8%)

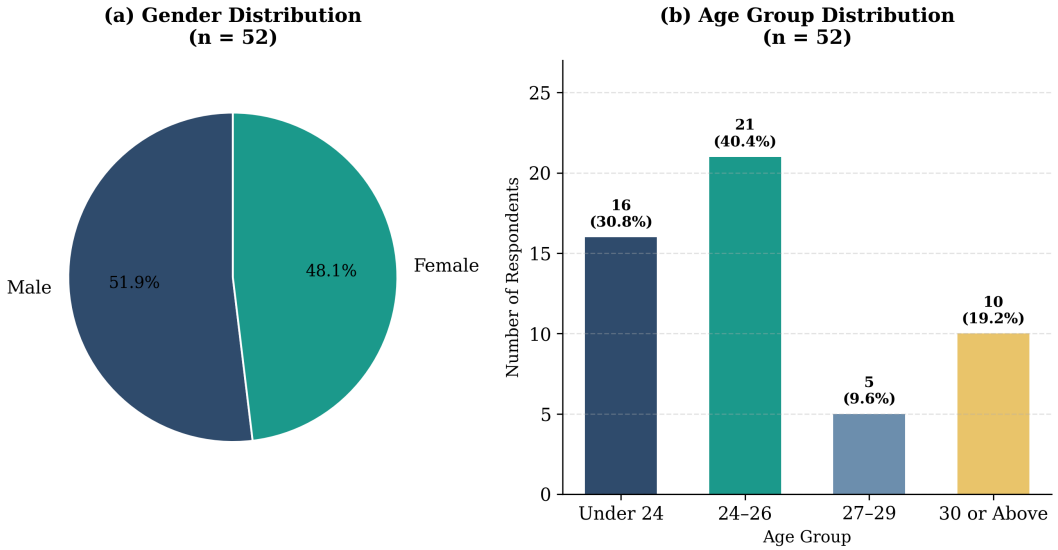


Figure 4.1: Distribution of Respondents by Gender and Age Group ($n = 52$)

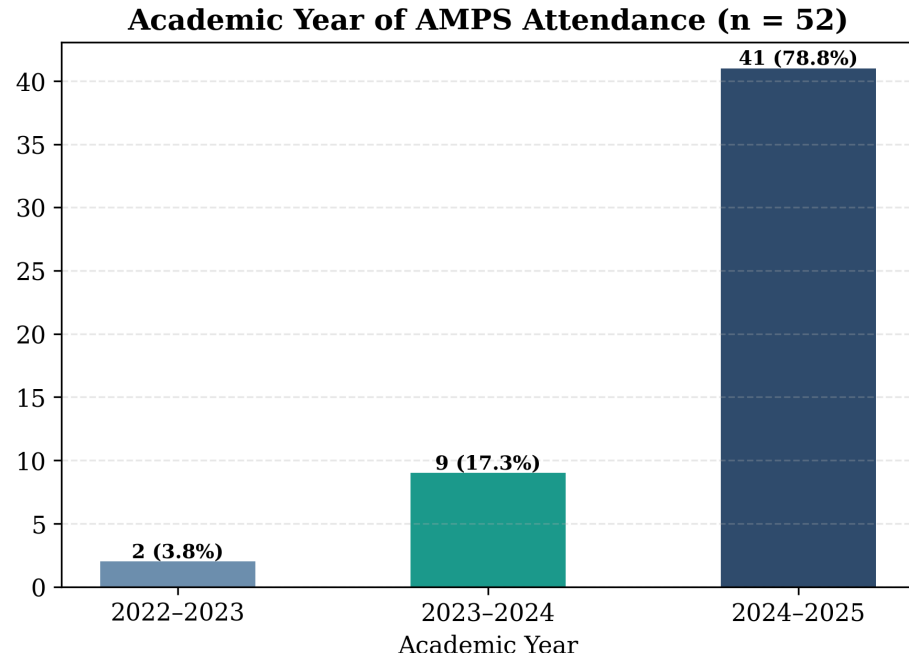


Figure 4.2: Distribution of Respondents by Academic Year of AMPS Attendance ($n = 52$)

4.2 Students' Use of AI Tools

Out of 52 valid responses, 47 students (90.4%) reported using at least one AI tool during the AMPS course, while 5 students (9.6%) reported that they did not use any AI tools. Figure 4.3 shows the distribution of AI tools used by the respondents.

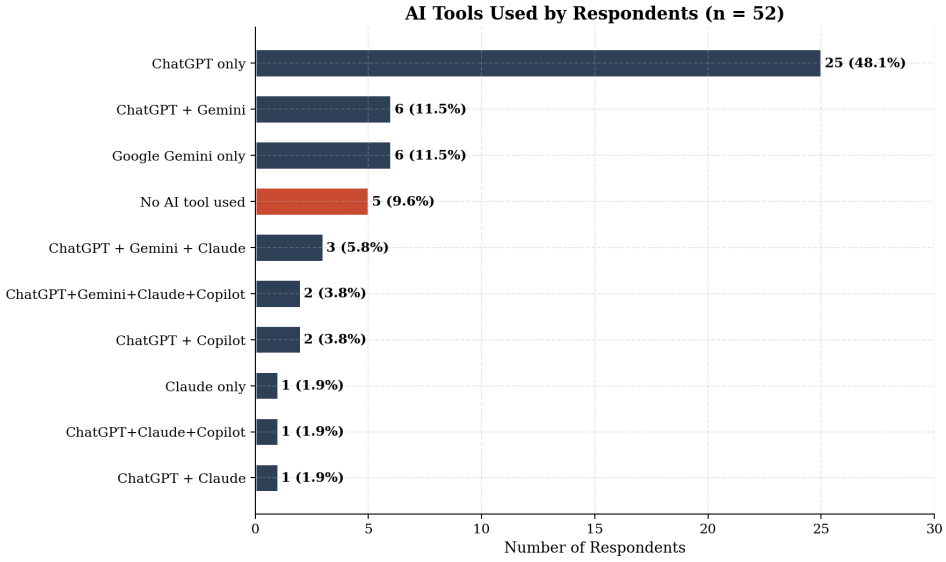


Figure 4.3: AI Tools Used by Respondents ($n = 52$)

Figure 4.3 shows that ChatGPT was the most commonly used AI tool among the

respondents. ChatGPT alone was used by 25 students (48.1%). Google Gemini alone was used by 6 students (11.5%), while another 6 students (11.5%) used ChatGPT together with Google Gemini. Smaller groups reported using ChatGPT in combination with Claude and Microsoft Copilot, whereas only one student (1.9%) reported using Claude alone. Finally, 5 students (9.6%) reported that they did not use any AI tools during the AMPS course.

The survey also asked how often students used AI tools during the course. As shown in Figure 4.4, the most common response was more than once a day ($n = 17$, 32.7%), followed by once a week ($n = 14$, 26.9%), once a month or less ($n = 11$, 21.2%), and once a day ($n = 10$, 19.2%). In total, 27 respondents (51.9%) reported using AI tools at least once a day.

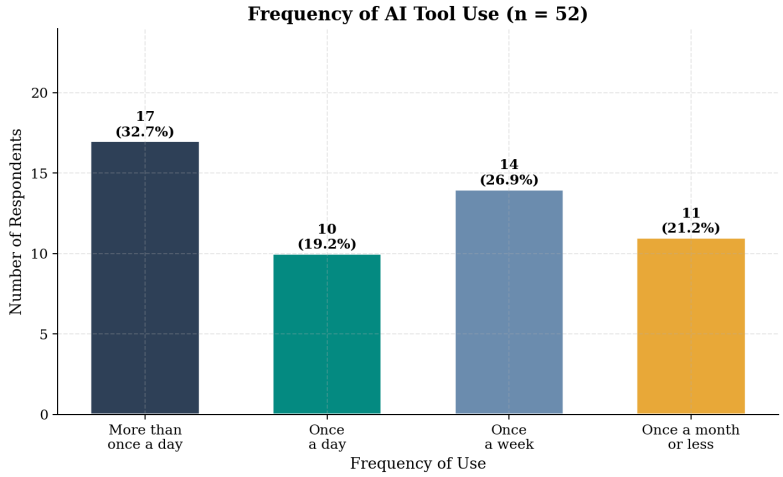


Figure 4.4: Frequency of AI Tool Use Among Respondents ($n = 52$)

4.2.1 AI Usage by Gender and Academic Year

In order to better understand the patterns of AI tool adoption, usage was also examined across gender and academic year groups.

Looking at AI tool usage by gender, both male and female students reported similarly high rates of AI tool use. As shown in Table 4.2 and Figure 4.5, 92.6% of male respondents and 88.0% of female respondents reported using at least one AI tool. The difference between the two groups was small.

Table 4.2: AI Tool Usage by Gender ($n = 52$)

Gender	Used at least one AI tool	Did not use AI tools	Total
Male	25 (92.6%)	2 (7.4%)	27
Female	22 (88.0%)	3 (12.0%)	25
Total	47 (90.4%)	5 (9.6%)	52

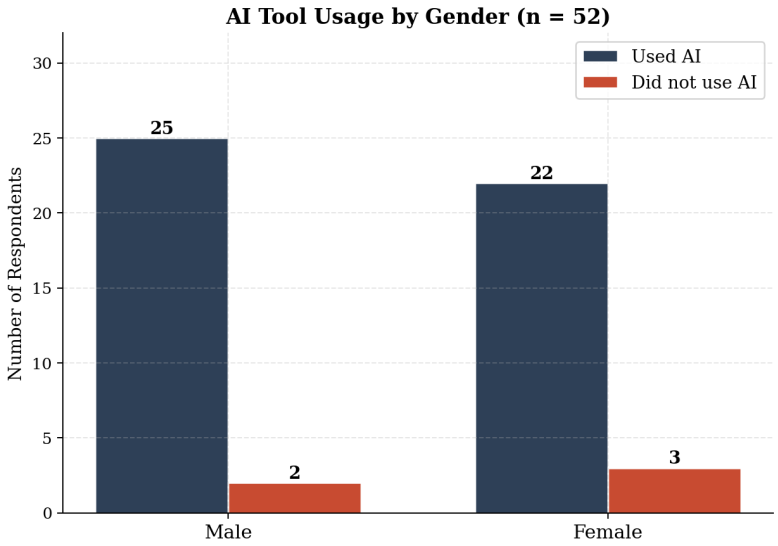


Figure 4.5: AI Tool Usage by Gender ($n = 52$)

As shown in Table 4.3, the number of students who reported using AI tools increased across the three academic years, from 2 in 2022–2023 to 37 in 2024–2025. The 2024–2025 cohort represented the largest proportion of the analysed sample.

Table 4.3: AI Tool Usage by Academic Year ($n = 52$)

Academic Year	Used at least one AI tool	Did not use AI tools	Total
2022–2023	2 (100%)	0 (0%)	2
2023–2024	8 (88.9%)	1 (11.1%)	9
2024–2025	37 (90.2%)	4 (9.8%)	41
Total	47 (90.4%)	5 (9.6%)	52

4.3 Descriptive Statistics of Survey Responses

The closed questionnaire comprised 14 Likert scale items, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Table 4.4 summarizes the distributions of the responses and the mean scores for all items. The following sections present the results for each group of items in more detail.

Table 4.4: Descriptive Statistics for All Likert Scale Items (SD=Strongly Disagree, D=Disagree, N=Neutral, A=Agree, SA=Strongly Agree) ($n = 52$)

Statement	SD	D	N	A	SA	Mean (SD)
Perceived Ease of Use (PEOU)						*Avg: 3.85*
Q1. The AI tool I used was easy to use	0%	5.8%	9.6%	53.8%	30.8%	4.10 (0.80)
Q2. I felt comfortable asking the AI tool questions about production system topics	1.9%	7.7%	15.4%	46.2%	28.8%	3.92 (0.97)
Q3. I could use the AI tool without additional assistance	7.7%	17.3%	21.2%	23.1%	30.8%	3.52 (1.31)
Perceived Usefulness (PU)						*Avg: 3.82*
Q1. The AI tool helped clarify the difficult concepts of the course	1.9%	11.5%	17.3%	46.2%	23.1%	3.77 (1.00)
Q2. The AI tool helped me solve problems and exercises of the course	7.7%	9.6%	19.2%	28.8%	34.6%	3.73 (1.25)
Q3. The AI tool improved my understanding of exercises and assignments of the course	5.8%	5.8%	9.6%	53.8%	25.0%	3.87 (1.05)
Q4. The AI tool helped me prepare for the exam of the course	3.8%	11.5%	9.6%	38.5%	36.5%	3.92 (1.13)
Behavioral Intention to Use (BI)						*Avg: 3.76*
Q1. I intended to use the AI tool regularly in the AMPS course	7.7%	15.4%	26.9%	38.5%	11.5%	3.31 (1.11)
Q2. I plan to continue using the AI tool for similar courses	1.9%	7.7%	19.2%	32.7%	38.5%	3.98 (1.04)
Q3. I would recommend using the AI tool for the AMPS course to other students	3.8%	7.7%	13.5%	36.5%	38.5%	3.98 (1.09)
Perceived Challenges & Limitations						*Avg: 4.00*
Q1. The AI tool sometimes provided incorrect solutions for numerical or analytical problems	0%	0%	15.4%	55.8%	28.8%	4.13 (0.66)
Q2. Answers from the AI tool were sometimes too general for detailed questions	1.9%	9.6%	15.4%	51.9%	21.2%	3.81 (0.95)
Q3. I feel the need to verify the AI tool answers using lecture notes or textbooks	1.9%	7.7%	13.5%	48.1%	28.8%	3.94 (0.96)
Q4. The AI tool does not work well for some specific AMPS problems	0%	5.8%	13.5%	46.2%	34.6%	4.10 (0.85)

4.3.1 Perceived Ease of Use

Perceived Ease of Use refers to the degree to which a person believes that using a technology is simple and effortless. The results for this construct are shown in Figure 4.6. The overall mean score was 3.85.

The results for Q1 show a positive attitude, with 84.6% of students agreeing or strongly agreeing that AI tools are easy to use and user-friendly overall. Only 5.8% disagreed with this statement, and no respondent selected "Strongly Disagree."

Students' views were also slightly positive regarding their comfort in asking AI questions about production system topics Q2, with 75.0% of students agreeing or strongly agreeing with the statement. About 25.0% of the remaining students were neutral, disagreed, or

strongly disagreed. Compared to Q1, where 84.6% of students agreed that AI tools were easy to use, the percentage of agreement was lower for Q2.

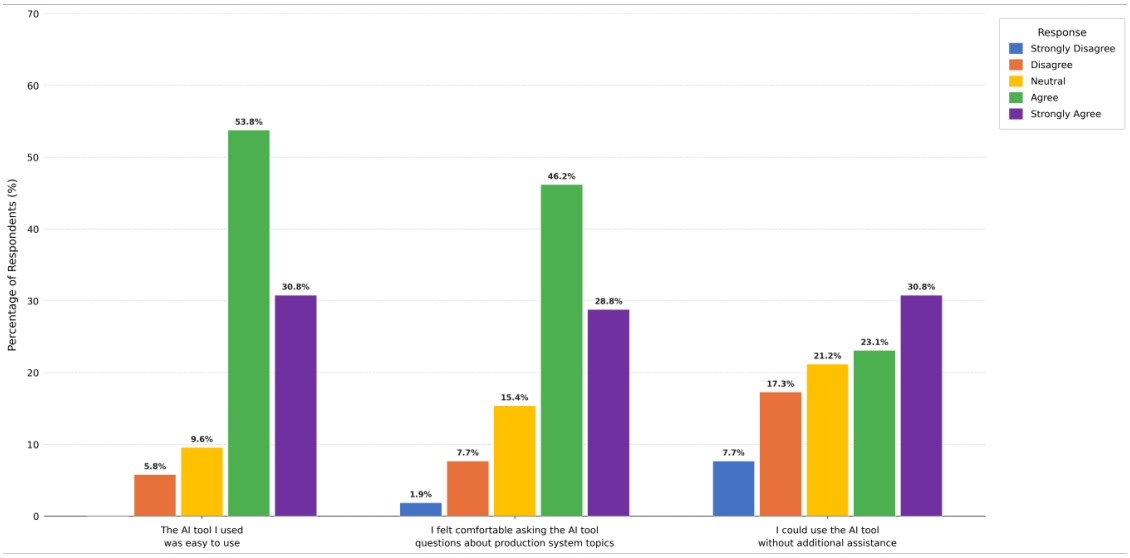


Figure 4.6: Perceived Ease of Use — Response Distribution (n = 52)

The final item, Q3, assessed whether students felt able to use AI tools independently without additional assistance. This item recorded the lowest mean score within the PEOU construct, with an average of 3.52. Overall, 53.9% of students agreed or strongly agreed with the statement, while 25.0% disagreed and 21.2% remained neutral. The combined percentage of neutral and negative responses reached 46.2%, showing greater variation in students' opinions. Given the analytical nature of the AMPS course, it is not surprising that students still relied on lecture notes and course materials alongside AI tools.

Overall, the three items indicate that students were generally comfortable using AI tools, although confidence levels varied across the three statements. Q3 received the lowest level of agreement.

4.3.2 Perceived Usefulness

Perceived Usefulness refers to the extent to which students believe that using AI tools can improve their learning and academic performance. This factor shows whether AI tools play a valuable role in understanding course concepts, completing assignments, solving exercises, and preparing for exams. This measure raises the following question: in which parts of the learning process do students benefit most from AI tools, and do students think that these digital tools improve their academic performance? The results are shown in Figure 4.7.

For Q1, 69.3% of management students agreed or strongly agreed that AI helped clarify difficult course topics. This indicates that many students considered AI useful for understanding course concepts. However, 30.7% of respondents gave neutral or negative responses, showing that students' opinions varied..

Moving from Q1 to Q2, students still showed a positive attitude toward using AI for

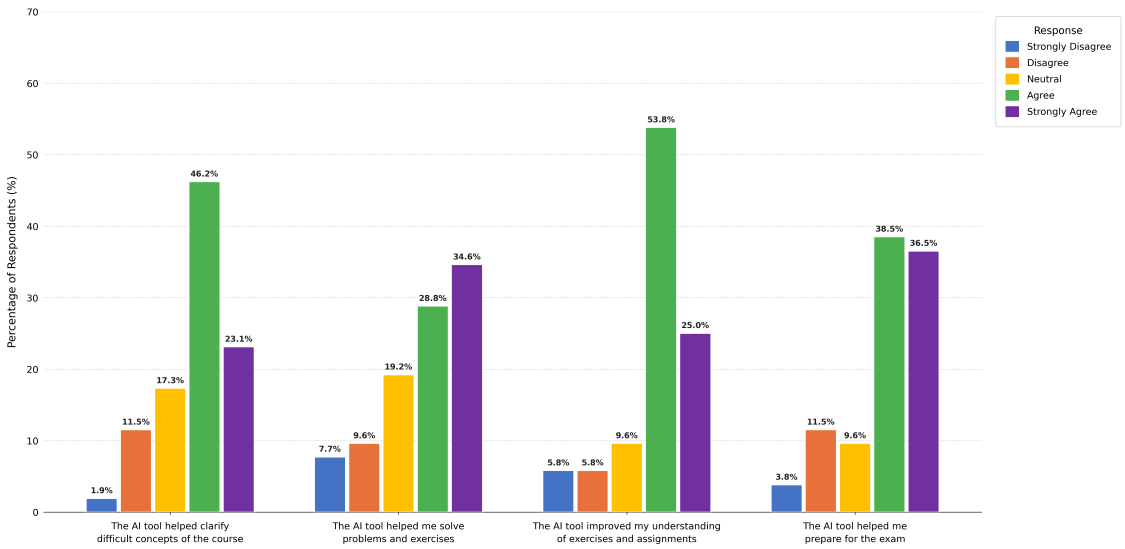


Figure 4.7: Perceived Usefulness — Response Distribution (n = 52)

solving exercises and problems. Although the overall result was positive, this statement had the lowest level of agreement among all items within this construct. Overall, 63.4% of students agreed or strongly agreed with the statement, while 36.6% of respondents gave neutral or negative responses, indicating more varied opinions for this item compared with the other Perceived Usefulness statements.

Students also found AI to be a useful tool for exam preparation. Regarding Q4, 75.0% of students agreed or strongly agreed that AI was a useful resource during exam periods. However, 25.0% of respondents did not agree with this statement, indicating that not all students considered AI equally useful for exam preparation.

The results across the four items reflect a consistently positive yet varied perception of usefulness among students. The AI tools were found to be most helpful in understanding assignments and exam preparation, while their role in solving analytical exercises remained more debated.

4.3.3 Behavioral Intention to Use

The Behavioral Intention to Use construct focuses on students' intentions to adopt AI technologies not only during the AMPS course but also in future learning activities. Specifically, it looks at students' willingness to keep using AI tools and to recommend them to their peers. Since students are generally more likely to continue using a technology when they have had a positive experience with it, this construct can be seen as an outcome of the previous factors. The results are presented in Figure 4.8.

With regard to Q1, which looked at students' intention to keep using AI in the AMPS course, the proportion of positive attitudes was only 50.0%. Notably, in Q2, students were asked about their intention to use AI in similar courses in the future. The proportion of positive attitudes for this question rose to 71.2%. Similarly, in Q3, which asked whether participants were willing to recommend the use of AI to other students, a positive attitude was expressed by 75.0% of students. This raises an interesting question: if participants

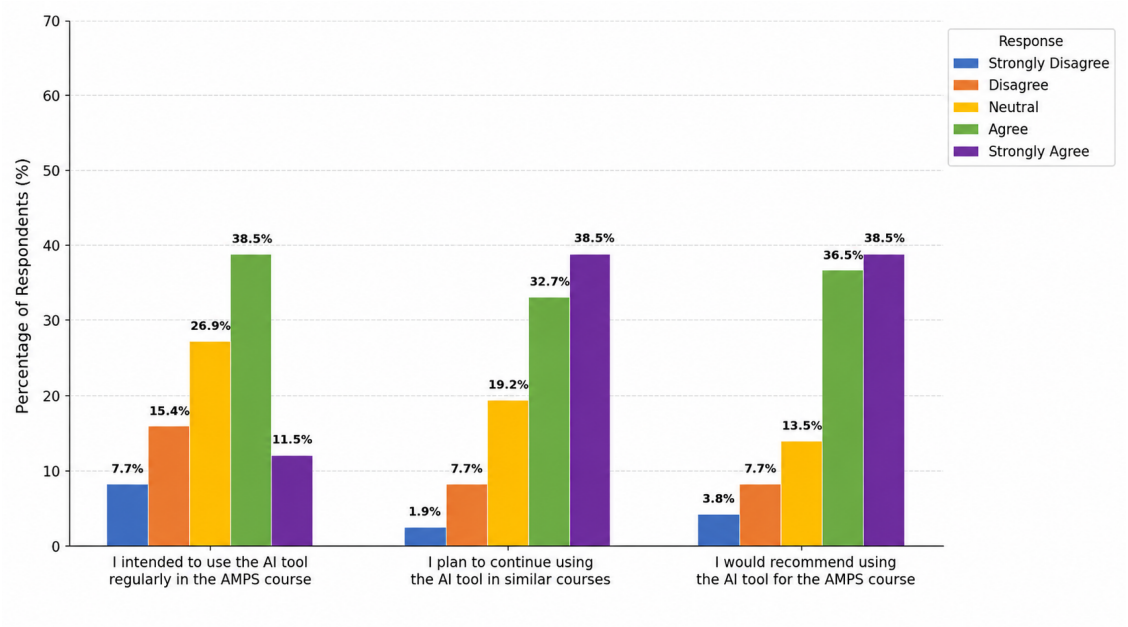


Figure 4.8: Behavioral Intention to Use — Response Distribution (n = 52)

had a good experience working with AI and were willing to recommend it, why did only half of them use it regularly while attending the AMPS course?

One possible reason for this is that participants were able to distinguish between the advantages and limitations of AI. While using AI, they recognised its usefulness for reviewing course material, obtaining quick explanations, improving their understanding of topics, and preparing for exams. At the same time, they also recognised that some AMPS concepts and exercises required deeper thinking and analytical reasoning. As a result, students appeared to use AI selectively, depending on the type of learning task.

4.3.4 Perceived Challenges and Limitations

Perceived Challenges and Limitations refers to the challenges that students may face when using AI tools in the learning process. While the previous factors focused on the positive aspects of AI adoption, this factor was included to explore the challenges faced by students when using AI tools in the AMPS course. More specifically, it looks at whether students had problems with incorrect answers, general explanations, the need to check data from AI, or limitations in handling particular issues related to their course. Figure 4.9 shows the results.

For Q1, 84.6% of students answered that AI tools sometimes provided incorrect solutions for numerical or analytical problems, meaning that most students had difficulty getting reliable solutions and answers. However, 15.4% of respondents remained neutral, and no students expressed disagreement with this statement. This result suggests that many students experienced situations where AI-generated answers were not completely accurate when dealing with calculations or analytical tasks. One reason could be that certain AMPS tasks require exact calculations and analysis. Hence, students realized that while

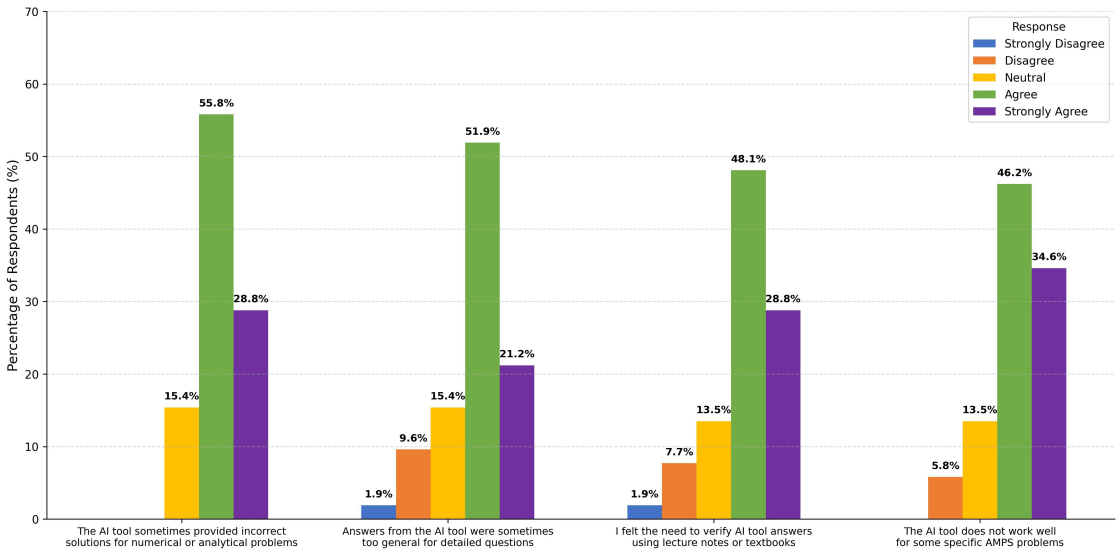


Figure 4.9: Perceived Challenges and Limitations — Response Distribution (n = 52)

AI can help provide explanations, it cannot necessarily be trusted to give the final numeric answer.

Another challenge explored in this study was whether AI tools could provide enough detail when answering questions related to the AMPS course. For Q2, since the course covers analytical topics such as production system modelling, queueing theory, and performance evaluation, students often need explanations that go beyond basic definitions. The results showed that 73.1% of students agreed that AI answers were sometimes too general for detailed questions, while 15.4% remained neutral and 11.5% disagreed. This suggests that although AI tools were useful for getting quick explanations and reviewing concepts, some students felt that the responses were not always detailed enough for the more specialised topics covered in the course. This is likely because AI tools are designed to provide general answers, whereas subjects such as AMPS often require deeper analysis and problem-specific reasoning. This finding may highlight one of the limitations of AI compared to human thinking abilities. In addition, the quality of the response may also depend on how the question is asked, meaning that more detailed prompts could help students get more relevant answers.

The third item, Q3, also supports the findings from the previous statements. Since many students believed that AI tools may sometimes give incorrect answers, it is understandable that they felt the need to check the information generated by these technologies against trusted academic sources.

The results showed that 76.9% of students agreed or strongly agreed with this statement. At the same time, 13.5% of respondents remained neutral, while only 9.6% disagreed. These results suggest that although students found AI useful, many still preferred to check AI-generated information using lecture notes and textbooks before accepting it as correct.

This can also be seen in Q4, where 80.8% of participants felt that AI tools do not work efficiently for some specific AMPS cases. On the other hand, 13.5% were neutral, while 5.8% did not agree. This implies that there are cases where AI tools cannot solve specific

AMPS problems.

This construct had the highest mean score overall, at 4.00. Students were aware of the capabilities and limitations of AI software, especially when it comes to solving mathematical problems that require numerical skills and analysis. It seems to be a common practice among most participants to check AI output against lecture materials.

4.4 Analysis of Open-Ended Questions

In this section of the survey, students were invited to share their personal experiences and opinions about using AI tools in the AMPS course. Unlike the previous sections, which consisted of Likert-scale items, these open-ended questions allowed participants to express their views in their own words. A total of 39 students responded to the first two open-ended questions, while 48 students answered the final question regarding the development of an AI tool specifically designed for the AMPS course. After analysing the responses, similar answers were grouped into common themes using thematic analysis. The results are presented in three main categories: the strengths of AI tools, the weaknesses of AI tools, and students' opinions on an AI chatbot for the AMPS course. Table 4.5 summarises the main themes identified from the responses.

Strengths of AI Tools

Understanding course concepts was one of the most frequently mentioned benefits, reported by 24 students. Many students explained that they turned to AI when they struggled to understand a topic from lectures or course materials. In such situations, AI often provided explanations that were easier to follow. As one student described: *"If I could not understand some theoretical concepts, AI helped me effectively using easier words than in the material."* Similar comments were made by other students who felt that AI helped them better understand topics that remained unclear after class. Another student stated: *"They aid in the simplification and compartmentalization of material into comprehensive and comprehensible information for me as a student. This aids me in understanding the material in a faster and more accurate manner."*

Exercise understanding was another benefit frequently mentioned by students, with 20 respondents referring to this aspect. Rather than using AI simply to get answers, many students used it to understand how to approach a problem when they were unsure where to start. As one student explained: *"When I didn't have a clear strategy in my mind to solve an exercise, asking AI was useful to give me a reasoning to follow."*

The responses also showed that many students saw AI as a starting point rather than a final source of information. They often used it to get a better understanding of a topic before checking the information against lecture notes, textbooks, or other course materials. One student described this approach as follows: *"Mostly AI was a first step for deeper understanding of some topics, avoiding classical literature research. Afterwards classical literature was used to verify AI answers."*

Not all students focused only on learning support. Some highlighted the role of AI in helping them manage their study time more efficiently. According to 8 respondents, AI was useful for creating summaries, organising notes, and quickly identifying important topics

Table 4.5: Summary of Advantages and Disadvantages Identified from Open-Ended Responses

Category	**Theme**	**Description**
Advantages	Concept clarification	Students frequently mentioned that AI made difficult concepts easier to understand. They appreciated receiving simpler explanations when lecture topics were confusing or complex.
	Exercise understanding	Many students said that AI helped them understand how to approach exercises. It often provided useful guidance when they were unsure how to begin solving a problem.
	Note organisation and time saving	Students appreciated AI for summarising information and organising study materials, making revision quicker and easier to manage.
	Exam preparation support	Several students reported using AI during exam preparation to review key topics, test their understanding, and identify areas that required further study.
Disadvantages	Inaccuracy in numerical tasks	The most common concern was that AI sometimes produced incorrect answers for numerical or analytical problems, making students cautious when checking calculations.
	Limited course-specific reasoning	Some students felt that AI struggled with the specific methods and reasoning required in the AMPS course. As a result, its answers did not always match the approaches taught during lectures.
	Answers too general	A number of students felt that AI explanations were sometimes too broad or lacked the level of detail needed for more specialised course topics.
	Risk of uncritical reliance	A few students expressed concern that relying too heavily on AI could reduce independent thinking and discourage them from checking information carefully.

before exams. This allowed them to spend less time searching through course materials and more time focusing on revision. As one student explained: *"By using this I can save my time and also get a useful summary of each part, both practical and theoretical, and also classify the exam questions based on the topic and also understand which questions during academic years are repetitive and most important."*

Exam preparation was another area where students reported positive experiences with AI tools, although it was mentioned less than the previous themes. A total of 7 respondents referred to this aspect. Students explained that AI helped them review important topics,

clarify doubts, and identify areas that needed additional study before exams. Some also felt that AI made the revision process more efficient by providing quick explanations and reducing the time needed to search through course materials. As one student stated: *"The AI tools helped me to understand complex concepts more easily and supported me to solve practical exercises step by step. They helped clarify doubts, review materials and save time for exam preparation."*

In general, some of the students who highlighted the advantages of AI also felt the need to point out its disadvantages. For instance, they believed that AI was very effective for understanding theoretical concepts but less effective for solving practical tasks and analysis. The fact that some students evaluated the use of AI critically shows a thoughtful and balanced perspective.

Weaknesses of AI Tools

When discussing the limitations of AI tools, the issue mentioned most often by students was their performance in numerical and analytical tasks. A total of 13 respondents raised concerns about this aspect. While many students found AI useful for understanding concepts and reviewing course material, they felt less confident using it for calculations and problem-solving activities. Several students reported getting incorrect answers in practical exercises and statistical problems. As one student stated: *"Practical problems: it does not make one correct exercise."* Similar concerns were expressed by others: *"It does not perform Erlang and other complex tasks." "It is useless to do any sort of calculation."* One student also pointed out that AI-generated solutions should be checked against course materials, explaining: *"Sometimes it gives you the wrong answers in calculation or statistical exercises. It should support by the subject materials as you exactly study."* These remarks indicate that although students found AI to be a helpful tool for learning purposes, they were quite aware that it was not always dependable for numerical analysis and computations.

Another limitation mentioned by students was that AI did not always follow the specific methods and approaches used in the AMPS course. A total of 9 respondents referred to this issue. Although AI responses often seemed reasonable, students noticed that they did not always match the explanations given during lectures. As one student stated: *"Sometimes taking information from the web doesn't follow exactly the course explanations."* Some students also pointed out that the same problem can often be solved in different ways, and that AI may not always use the approach expected by the lecturer. As another student explained: *"The risk of blind trust , the way of solving exercises depends also on how the professor does it; it is not universal."* These responses suggest that students did not always see AI as a complete substitute for course materials. Instead, they felt that AI-generated answers should be checked against the methods and approaches taught during the course.

Answers that were too general were another limitation mentioned by students, with 7 respondents referring to this issue. Although AI responses were not necessarily incorrect, some students felt that they often lacked the level of detail needed for the more specialised and analytical topics covered in the AMPS course. As one student stated: *"Always general answers... they rarely go in depth."* Another student explained that this issue

was particularly noticeable when solving exercises and problems: *"For solving problems and exercises, answers are usually too general and I need to ask other tools to make sure about responses."* These comments suggest that some students expected more detailed and in-depth explanations from AI, especially when dealing with topics that required deeper analysis and understanding.

A small number of students also raised concerns about relying too much on AI tools. Although this theme was mentioned by only 3 respondents, it highlights the importance of using AI critically rather than accepting its answers without checking them. One student explained: *"I think the main problem is when we use AI without reasoning: ChatGPT can still make mistakes, and without the previous study through the official material of the course the risk is to make even more confusion."* Another student expressed a similar concern: *"In my opinion, the main weakness is the fact that you cannot trust 100% the answers provided; you must be careful about possible hallucinations."* These comments suggest that students were aware that AI should be used as a support tool rather than a replacement for independent thinking and course materials.

Students' Views on an AI Chatbot Specific to the AMPS Course

The final question asked students whether they would find it useful to have an AI tool developed specifically for the AMPS course, or a chatbot. The results showed that 33 out of 48 respondents (68.8%) answered yes and 15 (31.2%) answered no, as shown in Figure 4.10.

This outcome may be related to some of the limitations discussed earlier. While students generally found AI useful, some felt that its answers were too general or not always aligned with the methods taught in the course. Therefore, a dedicated AMPS chatbot could provide more relevant and course-specific support.

Among the students who supported the idea, the most common reason was the expectation of getting more accurate and course-specific answers. Many felt that an AI tool trained directly on AMPS materials would give responses that are more closely aligned with the course content and teaching approach. Several students believed that such a tool could reduce the number of overly general answers and improve the reliability of the information provided. As one student stated:

"It would be more accurate than generic AI bots."

Similar views were expressed by other respondents:

"It could provide relevant answers based on the course material and help reduce general answers."

"To give students the possibility to have a clear and sure explanation checked by the professors."

Some students also felt that having a dedicated AI tool available throughout the course could improve their learning experience and overall understanding of the subject. As one student explained:

"Because having always accessible an AI tool specifically designed for the course could have a huge impact on the quality of my study session and my understanding at the end of the course."

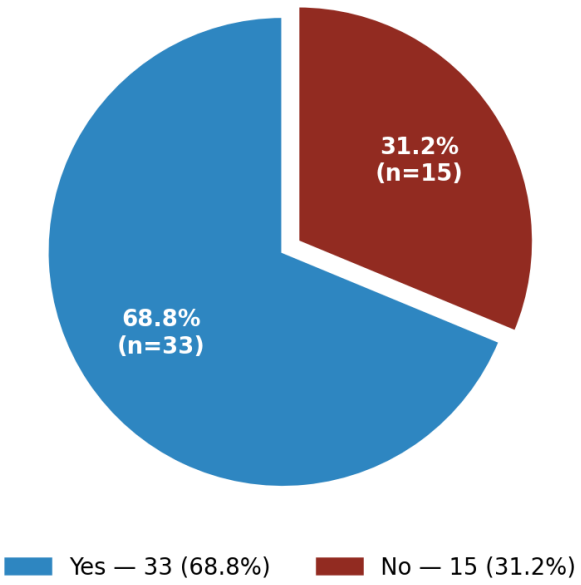


Figure 4.10: Student Interest in a Course-Specific AI Tool for AMPS (n = 48)

Accessibility was a third motivation. Some students pointed out that a dedicated tool would be especially valuable for those who cannot always attend class and depend more on self-study to keep up with the course.

A second reason mentioned by students was the need for guidance when solving exercises. Many felt that a course-specific AI tool could help them understand the steps needed to solve a problem using the same approach taught during the course, rather than giving general solutions. As one student noted:

"Maybe something more specific that can help solving step by step or giving a guide to students on how to solve the exercises."

Another student added:

"It will be interesting to compare my exercise solutions with the AI one."

Some students also believed that such a tool could be useful during exam preparation. As one student explained:

"Yes, I think it would be very useful because it could help students save time during the exam period and make it easier to summarise lecture slides and literature."

Among the 15 students who answered no, most felt that the existing AI tools were already good enough for their needs. Others preferred to rely on the course materials and the professor's explanations. Some students also pointed out that the usefulness of AI depends on each individual's study preferences. One respondent raised a technical concern, stating:

"A simple chatbot with RAG will not work. Try an agentic approach if you want to implement a chatbot. Otherwise, think about AI support for creating simulations, better studying materials, or employ software during workshops."

4.5 Chapter Summary

This chapter presented the results of the survey conducted among students who attended the AMPS course at Politecnico di Torino. It described students' AI usage patterns, their perceptions of AI tools in terms of ease of use, usefulness, behavioural intention, and perceived challenges. The chapter also summarised the main themes identified from the open-ended responses.

Overall, the results showed that students had both positive and critical views about using AI tools in the AMPS course. While many students found AI useful for learning and exam preparation, they also recognised several limitations, especially when working on numerical and analytical tasks. The next chapter discusses these findings in more detail, compares them with previous studies, and explains their implications for the use of AI in higher education.

Chapter 5

Analysis and Findings

5.1 Introduction

Chapter 4 examined the questionnaire one item at a time, presenting the percentages and mean score for each of the fourteen questions separately. In this chapter, the focus changes. Each of the 52 respondents is considered as one case, and their answers across all fourteen items are examined together. This makes it possible to look at overall response patterns rather than analysing each question separately.

To make this analysis possible, the fourteen Likert items first had to be reduced to a more manageable form. The items related to each of the four constructs of the extended Technology Acceptance Model—Perceived Ease of Use, Perceived Usefulness, Behavioral Intention, and Perceived Challenges and Limitations—were averaged to obtain one score for each construct and each respondent. As a result, each of the 52 respondents was represented by four scores, providing a clearer basis for comparing response patterns.

These scores were then compared across the groups already included in the questionnaire, such as AI tool used, gender, age, academic year, and frequency of use. However, some of these subgroups contained only a small number of respondents, in some cases as few as two or five. For this reason, the group averages should be interpreted as descriptive patterns rather than evidence that can be generalized to a wider population. The analysis in this chapter is therefore descriptive and should not be considered a statistical test.

5.2 Approach to the Analysis of Survey Responses

The four constructs include a total of fourteen items: three for Perceived Ease of Use, four for Perceived Usefulness, three for Behavioral Intention, and four for Perceived Challenges and Limitations. For each student, the score for each construct was calculated by taking the average of their responses to the items within that construct. This provided a simple and consistent way to summarize the answers of each respondent for the four constructs.

From this point onward, the four constructs are referred to using the abbreviations PEOU, PU, BI, and CH. For PEOU, PU, and BI, a higher score represents a more positive perception of AI tools. CH is interpreted differently. A higher CH score indicates that respondents experienced or agreed with more challenges and limitations, such as incorrect answers to numerical problems. Therefore, unlike the other three constructs, a high CH score should not be interpreted as a positive result.

With this approach established, the rest of the chapter compares the four construct scores across different groups, including AI tool used, gender, age, academic year, and frequency of use. The final part of the analysis then considers whether the patterns found in these comparisons are also reflected in students' open-ended responses.

5.3 Do Different AI Tools Influence Students' Perceptions?

Students who used more than one AI tool showed the highest scores in both Table 5.1 and Figure 5.1. Their average score was 4.38 for Perceived Usefulness and 4.29 for Behavioral Intention. These values were higher than those of students who used only ChatGPT, with scores of 3.78 and 3.61, and those who used only Gemini, with scores of 4.00 and 3.89. Overall, the results show that students who used multiple AI tools had more positive views of their usefulness and a stronger intention to continue using them.

Table 5.1: Average Scores by AI Tool Used (n = 52)

AI tool used	n	Ease of Use	Usefulness	Behav. Intention	Challenges
ChatGPT only	25	4.01	3.78	3.61	3.85
Gemini only	6	4.00	4.00	3.89	3.83
Claude only	1	4.00	3.75	3.67	3.75
Multiple tools	15	3.67	4.38	4.29	4.18
No AI tool used	5	3.33	2.15	2.73	4.40

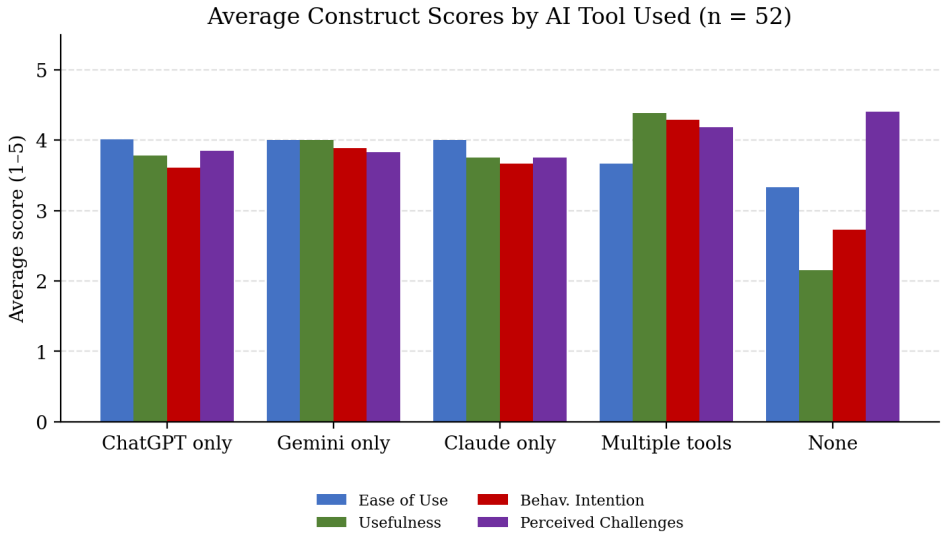


Figure 5.1: Average Scores by AI Tool Used (n = 52)

Ease of Use was very similar across the individual AI tools. ChatGPT, Gemini, and Claude all had scores close to 4.00, showing only small differences between them. However, students who used multiple AI tools reported a lower Ease of Use score of 3.67. This suggests that using several tools may be less straightforward than relying on a single tool.

A possible explanation can be found in the item-level results presented in Chapter 4.

Among the four Usefulness items, the lowest level of agreement was related to solving problems and exercises (63.4%), compared with improving the understanding of exercises and assignments (78.8%) and exam preparation (75.0%). This suggests that AI tools were more useful for understanding concepts and reviewing course material than for solving specific exercises. Students who used multiple tools may have used different tools for different tasks, which could explain their higher Usefulness score.

Among the five students who did not use any AI tool, the Usefulness (2.15) and Behavioral Intention (2.73) scores were the lowest in the sample. At the same time, this group reported the highest Challenges score (4.40). This shows that students who did not use AI had less positive views of its usefulness and future use, while also reporting greater concerns about its limitations. However, since this group included only five students, these results should be interpreted carefully and cannot be generalized

5.4 Do Male and Female Students Answer Similarly?

Male and female students showed relatively similar scores for Usefulness and Behavioral Intention, as shown in Table 5.2 and Figure 5.2. The average Usefulness score was 3.93 for male students and 3.71 for female students, while Behavioral Intention was 3.90 and 3.60, respectively. A clearer difference can be seen in Ease of Use, where male students reported a higher score of 4.09 compared with 3.59 for female students. For Challenges, the pattern was reversed, with female students reporting a slightly higher score of 4.15 compared with 3.85 for male students.

Table 5.2: Average Scores by Gender (n = 52)

Gender	n	Ease of Use	Usefulness	Behav. Intention	Challenges
Male	27	4.09	3.93	3.90	3.85
Female	25	3.59	3.71	3.60	4.15

Adoption rates were already close: 92.6% of men and 88.0% of women had used at least one AI tool, a gap of three or four points that hardly counts as a difference. So both groups picked up the tools at almost the same rate, rated their usefulness in almost the same way, and were almost equally inclined to keep using them. What differs is not whether AI got used, or how valuable it was judged to be, but how it felt to use it, easier, on average, for the men in this sample, and somewhat harder for the women.

5.5 Do Different Age Groups and Academic Years Have Similar Opinions?

5.5.1 Age Group

One difference can be seen in Ease of Use, as shown in Table 5.3. Students aged 27–29 reported the lowest score at 3.00, compared with scores ranging from 3.57 to 4.05 for the other age groups.

The other three constructs showed relatively small differences across the age groups, as also shown in Figure 5.3. Usefulness, Behavioral Intention, and Challenges remained within about half a point across all four groups. However, the 27–29 age group included

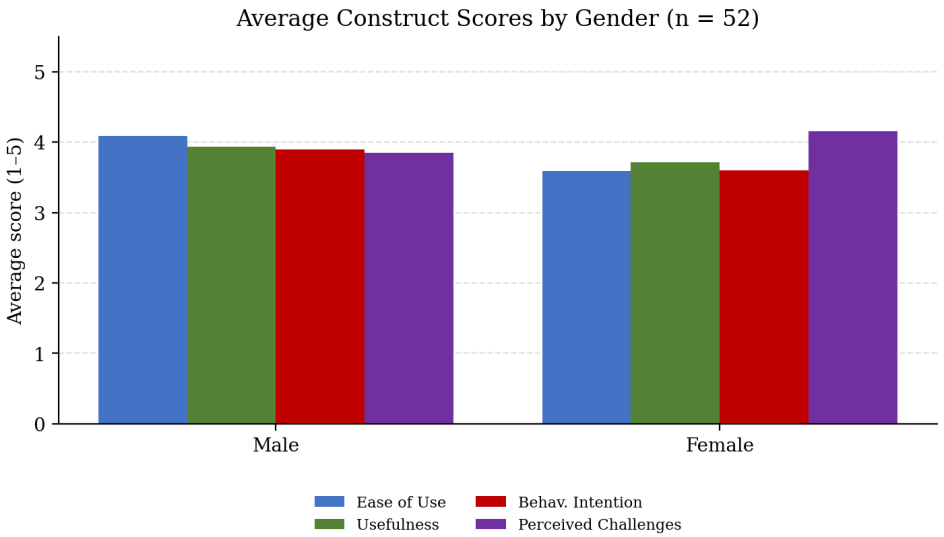


Figure 5.2: Average Scores by Gender (n = 52)

Table 5.3: Average Scores by Age Group (n = 52)

Age group	n	Ease of Use	Usefulness	Behav. Intention	Challenges
Under 24	16	4.02	3.91	3.75	3.91
24–26	21	4.05	3.76	3.76	3.96
27–29	5	3.00	3.75	4.00	4.05
30 or above	10	3.57	3.85	3.63	4.18

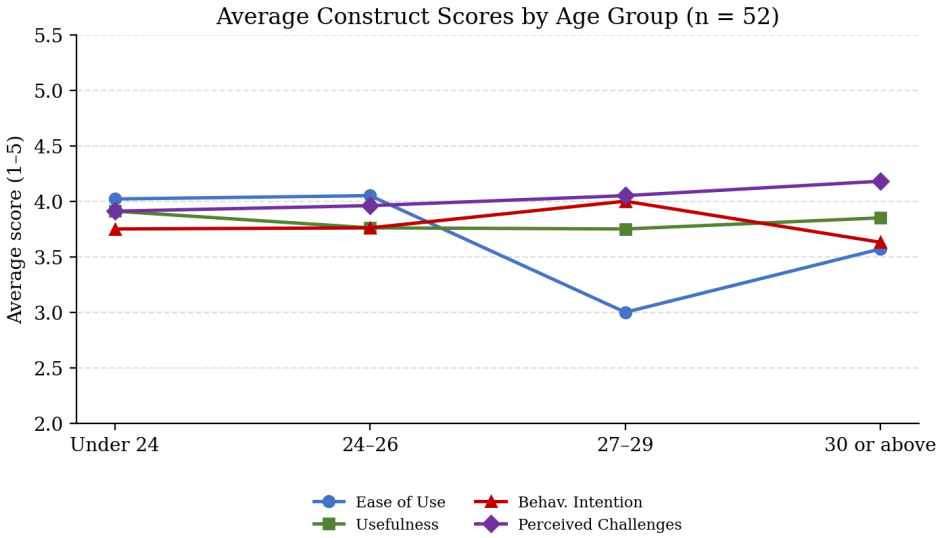


Figure 5.3: Average Scores by Age Group (n = 52)

only five respondents, representing 9.6% of the sample, so the lower Ease of Use score for this group should be interpreted carefully. Most respondents (71.2%) were under 26, while only 19.2% were aged 30 or above. Overall, the results show only small differences in students' perceptions of AI tools across age groups.

5.5.2 Academic Year of AMPS Attendance

Most respondents attended the AMPS course in 2024–2025, with 41 out of 52 students belonging to this group. In comparison, nine students attended in 2023–2024 and only two in 2022–2023. Therefore, the comparison across academic years should be interpreted carefully, as the groups are very different in size.

Table 5.4: Average Scores by Academic Year of AMPS Attendance (n = 52)

Academic year	n	Ease of Use	Usefulness	Behav. Intention	Challenges
2022–2023	2	3.50	3.38	3.33	3.75
2023–2024	9	3.85	4.36	4.15	4.31
2024–2025	41	3.86	3.73	3.69	3.94

The 2023–2024 group showed higher scores for Usefulness, Behavioral Intention, and Challenges compared with the other academic years. However, this group included only nine respondents, so these differences should be interpreted carefully. The 2024–2025 group included 41 of the 52 respondents and reported scores of 3.86 for Ease of Use, 3.73 for Usefulness, 3.69 for Behavioral Intention, and 3.94 for Challenges. Since most respondents belonged to this group, these results provide a more reliable picture of the overall sample.

5.6 Do Students Who Use AI Every Day Have More Positive Opinions?

Students who used AI most frequently showed much higher scores for Usefulness and Behavioral Intention, as shown in Table 5.5 and Figure 5.4. The most frequent users reported a Usefulness score of 4.32, compared with 2.84 for the least frequent users. Similarly, Behavioral Intention was 4.35 for the most frequent users and 2.76 for the least frequent users. These differences were the largest observed among the group comparisons in this chapter.

Table 5.5: Average Scores by Frequency of AI Tool Use ($n = 52$)

Frequency of use	n	Ease of Use	Usefulness	Behav. Intention	Challenges
Once a month or less	11	3.76	2.84	2.76	4.05
Once a week	14	3.95	3.95	3.71	3.79
Once a day	10	3.73	3.88	3.90	4.05
More than once a day	17	3.88	4.32	4.35	4.10

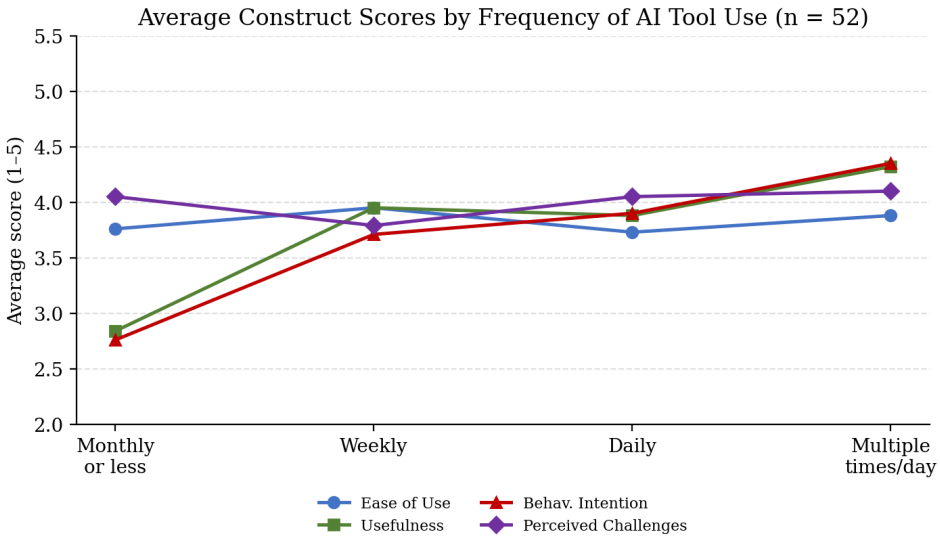


Figure 5.4: Average Scores by Frequency of AI Tool Use ($n = 52$)

Weekly and daily users showed scores between the least and most frequent users. Usefulness and Behavioral Intention generally increased as the frequency of AI use increased. However, Ease of Use and Challenges remained relatively similar across all four frequency groups, with scores between approximately 3.7 and 4.1. This suggests that more frequent AI use was mainly associated with higher perceived usefulness and a stronger intention to continue using AI, rather than with greater ease of use or fewer challenges.

This also helps explain the Behavioral Intention results presented in Chapter 4. Only 50.0% of respondents intended to use AI regularly in the AMPS course, compared with 71.2% who planned to use it in future courses and 75.0% who would recommend it to other students. When the results are compared by frequency of use, a clearer pattern appears. Frequent users reported a Behavioral Intention score of 4.35, while occasional users reported 2.76. This suggests that intention to continue using AI was much stronger among students who already used it frequently.

Frequent AI users reported a Challenges score of 4.10, which was very similar to the 4.05 reported by occasional users. This shows that more frequent use of AI was not associated with fewer perceived challenges. Even students who used AI regularly remained aware of its limitations and the need to check AI-generated answers against course materials.

5.7 Checking the Patterns Against the Open-Ended Answers

The open-ended responses were also used to compare students' written comments with their answers to the Likert-scale questions. In particular, the analysis considered whether students who mentioned a specific concern in their written responses gave different scores on the related Likert item compared with students who did not mention the same concern. The aim of this comparison was to identify possible patterns between the qualitative and quantitative responses. However, these differences were used only as descriptive

observations and were not considered as formal statistical evidence.

The most frequently reported concern was incorrect numerical or calculation answers, which was mentioned by 10 students. Table 5.6 compares the Challenges scores of students who mentioned each concern in their open-ended responses with the scores of those who did not mention the same concern. This comparison provides an indication of whether the concerns expressed in the written responses were also reflected in students' Likert-scale answers

Table 5.6: Weakness Themes Compared with the Challenges Score ($n = 52$)

Weakness theme (open-ended)	**n**	**CH (mentioned)**	**CH (not mentioned)**
Numerical or calculation errors	10	4.00	3.99
Answers too general / lacking detail	6	4.46	3.93
AI method different from course method	4	4.12	3.98

This result is not surprising, as 84.6% of respondents had already agreed that incorrect numerical or calculation answers were a challenge. Since this concern was shared by a large proportion of students, mentioning it in the open-ended responses did not lead to a clear difference in the Challenges scores between those who mentioned it and those who did not.

Students who described AI answers as "too general" showed a clearer difference. Although only six students mentioned this issue, their average Challenges score was 4.46, compared with 3.93 for the other respondents. This concern was also common in the closed-ended questions, where 73.1% of respondents agreed that AI answers could be too general. However, students who specifically mentioned this issue in their written responses had a higher overall Challenges score, suggesting that they were more concerned about the limitations of AI tools.

Students who mentioned that the AI method was different from the course method had a slightly higher Challenges score (4.12) than the other students (3.98). However, the small difference suggests that this concern was specific to some students rather than being related to a much higher overall level of challenges with AI.

Table 5.7 shows only small differences between the two groups for both strength themes. Students who mentioned that AI helped them clarify difficult concepts had an average Usefulness score of 3.86, compared with 3.80 for those who did not mention this benefit. Similarly, students who mentioned that AI helped them approach exercises had an average Usefulness score of 3.82, which was almost the same as the score of students who did not mention this benefit.

Table 5.7: Strength Themes Compared with the Usefulness Score ($n = 52$)

Strength theme (open-ended)	**n**	**PU (mentioned)**	**PU (not mentioned)**
Helped clarify difficult concepts	20	3.86	3.80
Helped understand how to approach exercises	17	3.82	3.82

The benefits mentioned by students in their open-ended responses seem to reflect the

aspects they considered most relevant, rather than a stronger or weaker overall view of AI. However, when the results for strengths and weaknesses are compared, a small pattern can be observed. Students who mentioned specific weaknesses tended to have higher Challenges scores, while mentioning a particular benefit showed little difference in Usefulness scores. This is also consistent with the overall results, where Challenges had the highest average score among the four constructs, at 4.00, compared with 3.82 for Usefulness.

Table 5.8 compares students who were interested in a dedicated AMPS chatbot with those who were not. The clearest difference was observed in the Challenges scores. The 33 students who expressed interest in a dedicated chatbot had an average Challenges score of 4.14, compared with 3.68 for the 15 students who did not. A smaller difference was found for Usefulness, with average scores of 3.93 and 3.62, respectively.

Table 5.8: Interest in a Dedicated Chatbot Compared with Challenges and Usefulness Scores ($n = 52$)

Interested in a dedicated AMPS chatbot?	**n**	**Avg. Challenges**	**Avg. Usefulness**
Yes	33	4.14	3.93
No	15	3.68	3.62

This suggests that students' interest in a dedicated AMPS chatbot was more closely related to the challenges they experienced with existing AI tools than to their overall perception of usefulness. Students who reported greater challenges were more likely to express interest in a chatbot designed specifically for the AMPS course.

5.8 Summary of Main Findings

no in english simple way

Two main points can be seen from these comparisons. First, students who used AI more often or used more than one AI tool generally found AI more useful and were more willing to continue using it. However, using AI more often did not mean that students found it easier to use or experienced fewer challenges. Gender showed a different pattern, with clearer differences in Ease of Use and Challenges. Age and academic year did not show clear differences, although some groups were quite small.

Students who were interested in a dedicated AMPS chatbot also had higher Challenges scores than those who were not interested. This may mean that their interest in an AMPS chatbot was partly related to the problems they experienced with existing AI tools. The open-ended responses also showed an interesting pattern. Common concerns, such as numerical errors, did not show much difference between students who mentioned them and those who did not. However, students who specifically mentioned that AI answers were too general had higher Challenges scores. Overall, students generally found AI useful and wanted to continue using it, while still recognising its limitation

5.9 Comparison with Previous Literature

The findings of this chapter are broadly consistent with the literature reviewed in Chapter 2, although some of the respondent-level patterns identified in this study have not been

examined directly in previous research. The comparison with earlier studies is therefore useful for interpreting the results, but it should not be understood as evidence that the same mechanisms necessarily operated in the present sample.

One of the clearest findings was that students who used multiple AI tools reported higher Perceived Usefulness and Behavioural Intention than those who relied on a single tool. This pattern can be considered alongside the discussion in Section 2.2.3, where generative AI tools were presented as offering different and potentially complementary forms of support. Dwivedi et al. (2023) and Kasneci et al. (2023), for example, discuss the broad range of educational tasks for which generative AI may be used, including explanation, information retrieval, writing support, and problem-solving. From this perspective, the higher scores of multiple-tool users may reflect access to a wider range of functions and responses. However, the present data do not identify why students selected multiple tools or which specific combination of functions they found most useful. This interpretation should therefore be treated as plausible rather than conclusive.

The relationship between frequency of use, Perceived Usefulness, and Behavioural Intention is also consistent with the general logic of the Technology Acceptance Model. Davis (1989) identified perceived usefulness as an important factor in a person's intention to adopt and continue using a technology. Similarly, Li, Li and Qiao (2025) reported a positive relationship between the use of large language model tools and students' perceptions of their educational value. In the present study, students who used AI more frequently reported higher Usefulness and Behavioural Intention scores. Nevertheless, frequency was not associated with a clear improvement in Ease of Use or with lower Challenges scores. Frequent users therefore appeared to value AI more and to show a stronger intention to continue using it, while remaining aware of its practical and academic limitations.

The results concerning gender provide a less direct comparison with previous studies. Male and female respondents reported relatively similar levels of Usefulness and Behavioural Intention, while a larger difference appeared in Ease of Use, with male respondents reporting a higher average score. Female respondents also reported a slightly higher Challenges score. The literature reviewed in Chapter 2 does not provide a directly comparable analysis of these four constructs among male and female engineering students. For this reason, the gender pattern identified here should be presented as a descriptive finding specific to this sample, rather than as confirmation or contradiction of an established result. Further research with a larger and more balanced sample would be required to determine whether this difference is consistent across other engineering courses and institutions.

Age and academic year showed no clear or stable relationship with the four construct scores. The limited age differences are broadly compatible with the review by Chu, Hwang, Tu and Yang (2022), in which age was not identified as one of the main factors shaping the educational acceptance of AI. However, this comparison must be made cautiously. The current sample was concentrated within a relatively narrow age range, and some age and academic-year groups contained very few respondents. The absence of a clear pattern may therefore reflect the composition of the sample rather than the complete absence of age- or cohort-related differences.

At a more general level, the findings support the view that students' attitudes towards

generative AI are positive but not uncritical. Respondents generally considered AI useful and expressed an intention to use it in future learning activities, while also reporting substantial concerns about incorrect numerical answers, overly general responses, and differences between AI-generated methods and those taught in the course. This combination of perceived value and caution is consistent with Sandu, Gide and Elkhodr (2024) and Deng and Joshi (2024), who describe students as recognising the educational potential of generative AI while remaining concerned about its reliability and appropriate use.

The interest in a dedicated AMPS chatbot adds a course-specific dimension to this discussion. Students who expressed interest in such a tool reported a higher average Challenges score than those who were not interested. This indicates that demand for a dedicated chatbot may arise not only from general enthusiasm for AI, but also from dissatisfaction with the limitations of general-purpose tools. This interpretation is compatible with Rahim, Iahad, Yusof and Al-Sharafi (2022), who emphasise trust and reliability in the acceptance of institutional chatbots. It is also consistent with Sánchez-Vera (2025), whose subject-specific chatbot was designed to provide support better aligned with the content and requirements of a particular learning context. For AMPS students, a dedicated tool could therefore be valuable if it provided answers that were more closely connected to course terminology, problem-solving methods, and teaching materials.

Finally, the comparison between the closed-ended scores and the open-ended responses shows that the two types of data provide related but not identical information. Incorrect numerical answers were widely recognised across the sample, and respondents who mentioned this issue spontaneously did not have a higher overall Challenges score than those who did not mention it. By contrast, students who independently described AI answers as too general had a noticeably higher Challenges score. This suggests that a widely shared concern may not distinguish more critical respondents, whereas a more specific concern may reveal a stronger negative evaluation of existing tools.

This result is relevant to the concerns raised by Kasneci et al. (2023) regarding plausible but inaccurate AI-generated responses in educational settings. General-purpose AI tools may produce answers that appear convincing without following the methods, level of detail, or standards expected in a particular course. The findings of this study therefore support the need for careful verification of AI-generated content and, where a course-specific tool is developed, close alignment with validated teaching materials and the problem-solving approaches used in AMPS.

5.10 Limitations of the Study

This study has some limitations. First, only 52 students responded, and most of them (78.8%) were from the 2024–2025 academic year. This means the results may not reflect the experiences of students from earlier years, many of whom had already graduated and could not be reached.

Second, the data came only from self-reported surveys, which can be affected by memory bias and the tendency to give socially desirable answers. Using interviews or direct observation alongside surveys could give a deeper understanding in future work.

Third, the study focused on a single course (AMPS) at one institution, so the results may not apply to other courses or universities.

Finally, the study did not measure academic performance, such as grades or exam scores. Therefore, it cannot show whether using AI tools actually improved student outcomes.

5.11 Chapter Summary

At the respondent level, the results provide a broader picture than the findings presented in Chapter 4. Frequent use and the use of multiple tools were associated with higher Usefulness and Behavioural Intention, while no clear differences appeared for Ease of Use or Challenges. Gender showed clearer differences in Ease of Use and Challenges, while age and academic year showed no consistent patterns. Interest in a dedicated AMPS chatbot was also more common among students who reported greater challenges with the existing tools.

Overall, the findings are consistent with the literature discussed in this chapter. Students generally found the tools useful and intended to continue using them, while still reporting important limitations in their use within the AMPS course.

Chapter 6

Conclusion and Future Work

6.1 Conclusion

This thesis explored how students in the Analysis and Management of Production Systems (AMPS) course at Politecnico di Torino use generative AI tools and how they perceive their role in supporting learning. The study was motivated by the increasing presence of AI in higher education and the need to better understand how these technologies are used in an engineering course, where analytical reasoning and structured problem-solving are essential. To investigate this topic, the Technology Acceptance Model (TAM) was used as the theoretical framework, and data were collected through a questionnaire completed by students attending the course.

The results show that AI has become part of many students' daily learning activities. ChatGPT was the most widely used tool, with more than half of the respondents relying on it as their primary AI assistant. Students mainly used AI to clarify concepts, review course material, prepare for examinations, and receive guidance when approaching exercises. These findings suggest that students see AI as a practical learning resource that can make studying more efficient and help them better understand complex topics.

At the same time, the study shows that students are aware of the limitations of current AI systems. While they appreciate the speed and accessibility of these tools, they also recognise that AI does not always provide accurate or course-specific answers. Many respondents reported checking AI-generated information using lecture notes or other reliable sources before accepting it. This behaviour suggests that students do not simply rely on AI but instead combine it with traditional learning resources and their own judgement.

The analyses presented in this thesis also show that students' experiences with AI are influenced more by how they use these tools than by their personal characteristics. Students who used AI more regularly and those who explored different AI systems generally reported more positive experiences than students who relied on a single tool. In contrast, only small differences were observed across age groups and academic years. These findings indicate that experience with AI and the ability to choose the most suitable tool for a specific task may be more important than demographic factors.

The findings are consistent with much of the existing literature on AI adoption in higher education. Similar to previous studies, students considered AI easy to use and

useful for supporting their learning, while also recognising the need to verify AI-generated information. However, this study also provides evidence from a specific engineering course, showing that the expectations of engineering students extend beyond obtaining correct answers. They also expect AI to follow the reasoning process and methodology used during the course. This highlights an important difference between general-purpose AI systems and educational tools designed for a specific learning context.

One of the most interesting findings of this study is the strong interest in a dedicated AI assistant for the AMPS course. Nearly 69% of the respondents supported this idea, suggesting that many students believe a course-specific system could provide explanations that are better aligned with the teaching approach adopted during lectures. This finding reflects a broader expectation that future educational technologies should not only provide information but also support the way students are expected to think and solve problems within a particular subject.

Overall, this study shows that generative AI has become a valuable support for learning, but it is not viewed as a replacement for lecturers, textbooks, or independent study. Instead, students appear to benefit most when AI is used responsibly alongside traditional learning resources. As these technologies continue to develop, universities will have the opportunity to integrate them more effectively into teaching while continuing to promote critical thinking, analytical reasoning, and independent learning. Although this research focused on a single course, it provides useful insights into how engineering students currently use AI and offers a foundation for future work in this area.

6.2 Future Work

This study also opens several opportunities for future research.

The first direction is the development of a chatbot specifically designed for the AMPS course. Since many students expressed interest in this type of system, future work could investigate whether a chatbot trained on validated course material provides more accurate explanations and follows the same problem-solving approach adopted during lectures.

Another direction would be to follow the same group of students throughout the course. Collecting data at different stages of the semester would provide a better understanding of how students' perceptions change as they gain more experience with AI. Relating these findings to examination results could also provide further evidence of how AI influences learning.

Future research could also compare AI-generated solutions with the solutions provided by the course instructor. Such a comparison would identify where current AI systems successfully follow the methodology taught in the course and where improvements are still needed.

Finally, repeating this study in other engineering courses and at different universities would help determine whether the findings reported in this thesis are specific to the AMPS course or reflect broader trends in engineering education. A larger and more diverse sample would provide a more comprehensive understanding of how students use AI across different learning environments.

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Appendix A

Questionnaire

Questionnaire

Use of AI Tools in the Course “Analysis and Management of Production Systems” (AMPS)

Dear students,

You are invited to participate in a research study investigating the use of artificial intelligence tools to support learning in higher education. This questionnaire specifically aims to examine how AI tools have been used in the context of the course *Analysis and Management of Production Systems* (AMPS).

Participation in this study is entirely voluntary. All responses will be collected anonymously, and no personally identifiable information will be gathered. You are kindly asked to answer the questions by referring exclusively to your experience within the AMPS course, without considering the use of AI tools in other courses or contexts.

The data collected will be used solely for academic research purposes. All responses will be treated with strict confidentiality and analyzed in aggregate form only.

The questionnaire is expected to take approximately 5–10 minutes to complete.

By proceeding with the questionnaire, you confirm that you have read and understood the information provided above and that you voluntarily agree to participate in this study.

Thank you for your cooperation.

Prof. Giulia Bruno

* Indicates required question

Background Information

1. What is your gender?

   Mark only one oval.

   - ◯ Male
   - ◯ Female
   - ◯ other
   - ◯ Prefer not to say

2. What is your age group? *Questionnaire*

Mark only one oval.

- ◯ under 24
- ◯ 24-26
- ◯ 27-29
- ◯ 30 or above

3. In which academic year did you attend the AMPS course? *

Mark only one oval.

- ◯ 2022-2023
- ◯ 2023-2024
- ◯ 2024-2025
- ◯ 2025-2026
- ◯ Other: _____

4. Indicate if you used an AI tool during the AMPS course to support your learning *

Tick all that apply.

- ☐ Yes, I used ChatGPT
- ☐ Yes, I used Google Gemini
- ☐ Yes, I used Claude
- ☐ Yes, used Microsoft Copilot
- ☐ No, I have not used any AI tools for the AMPS course
- ☐ Other: _____

5. How often do you use AI tools to understand AMPS concepts or solve problems during the course? *

Mark only one oval.

- once a month or less
- once a week
- once a day
- more than once a day

Perceived Ease of Use

6. For the following statements, please indicate your level of agreement *

Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The AI tool I used was easy to use					
I felt comfortable asking the AI tool questions about production system topics					
I could use the AI tool without additional assistance					

Perceived Usefulness

7. For the following statements, please indicate your level of agreement * Obbligatorio

Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The AI tool helped clarify the difficult concepts of the course	◯	◯	◯	◯	◯
The AI tool helped me solve problems and exercises of the course	◯	◯	◯	◯	◯
The AI tool improved my understanding of exercises and assignments of the course	◯	◯	◯	◯	◯
The AI tool helped me prepare for the exam of the course	◯	◯	◯	◯	◯

Behavioral Intention to Use

8. For the following statements, please indicate your level of agreement * Required

Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I intended to use the AI tool regularly in the AMPS course					
I plan to continue using the AI tool for similar courses					
I would recommend using the AI tool for the AMPS course to other students					

Perceived Challenges / Limitations

9. For the following statements, please indicate your level of agreement * Required

Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
The AI tool sometimes provided incorrect solutions for numerical or analytical problems					
Answers from the AI tool were sometimes too general for detailed questions					
I feel the need to verify the AI tool answers using lecture notes or textbooks					
The AI tool do not work well for some specific AMPS problems					

Open-Ended Questions

Questionnaire

Please share your opinions about using AI tools in the AMPS course.

10. In your opinion, how do AI tools supported you in the theoretical or practical parts of the AMPS course?

11. What do you think are the main weaknesses or limitations of using an AI tool in the AMPS course?

12. Do you think it would be useful to have an AI tool specifically designed for the AMPS course (e.g., a chatbot trained on the course material and capable of answering only AMPS-related questions)?

Mark only one oval.

- Yes
- No

13. If yes, why? *Questionnaire*

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