



Engineering Students' Perceptions of using Artificial Intelligence Tools in Higher Education: A Phenomenographic Study

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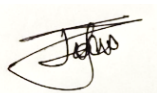
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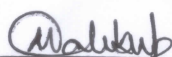
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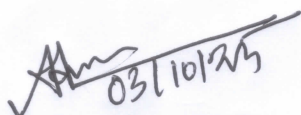
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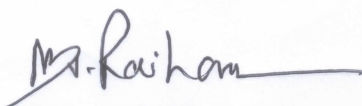
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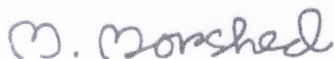
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DEDICATION

I dedicate this achievement to the Almighty ALLAH, for giving the strength and courage to complete this thesis work.

I commit this thesis work to my parents, brothers, sisters, and friends who have stayed with me during this period and encourage me to complete this degree. May Allah bless you all.

ACRONYMS

ABBREVIATIONS

EEE

MPE

CSE

CEE

IUT

AI

OIC

GAI

ACRONYMS

Electrical and Electronic Engineering

Mechanical and Production Engineering

Computer Science and Engineering

Civil and Environmental Engineering

Islamic University of Technology

Artificial Intelligence

Organization of Islamic Cooperation

Generative Artificial Intelligence

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Abstract

Artificial Intelligence (AI) has become an integral part of teaching and learning practices in higher education. This research investigates how engineering students perceive the use of AI within their academic environment. Guided by a phenomenographic approach, the study employed semi-structured interviews to explore variations in students' conceptions. Participants were drawn from different engineering departments Electrical and Electronic Engineering (EEE), Mechanical and Production Engineering (MPE), Computer Science and Engineering (CSE), and Civil and Environmental Engineering (CEE) at the Islamic University of Technology. Analysis of the interview data revealed five distinct ways students understand and experience AI in their studies. They viewed AI as a) an essential academic aid, b) a facilitator of personalized learning, c) as an administrative and teaching tool, d) an inhibitor to critical thinking, and e) an ethical challenger. These insights carry theoretical, pedagogical, and institutional implications for developing responsible and inclusive AI integration policies in higher education.

Keywords: Artificial Intelligence, student perception, higher education, phenomenography, engineering

Chapter 1 Introduction

1.0 Background of the Study

In recent years, the integration of artificial intelligence into education has been on the rise, drawing significant attention from the academic community. The rapid progress of AI technologies has introduced innovative ways to transform teaching practices and strengthen student achievement (Chen et al., 2020). Besides, tertiary institutions are looking for ways to enhance their students' educational experience to be more efficient and to develop new methods for both teaching and learning.

As AI continues to find broader applications in universities, researchers are increasingly examining how students understand and use such technologies in their learning experiences.(Slimi et al., 2025). Emerging AI tools now influence everyday academic work how students plan tasks, seek explanations, and produce assignments. In the educational context, AI technology could reduce the growing cost of education, help address shortages of trained instructors and teaching materials, and improve instruction access, quality, effectiveness, and efficiency (Alam, 2021). In addition, the use of artificial intelligence in ones learning could offer interaction between the learner and the tool to fulfill the individual needs of the learners (Tapalova & Zhiyenbayeva, 2022). In the last decade, considerable groundbreaking advances have been implemented in educational systems, and artificial intelligence has gained an enormous amount of attention and has been incorporated into many areas of education (Ahmad et al., 2021).

Previous studies highlight the importance of the selected topic and underscore the necessity for a more comprehensive examination of how artificial intelligence technology is utilized in education. To effectively implement AI technologies in higher educational settings, understanding how AI is perceived is crucial, particularly by students. Few researches have investigated student view about the use of AI from different perspectives. For example, how students perceive and interact with AI dictates how they use AI, which may lead to cognitive engagement and eventually affect the learning outcomes (Banele, 2023). Additionally, AI usage may vary depending on how students perceive the potential benefits, such as individual learning, and challenges, such as ethical concerns (Kumar & Raman, 2022). Moreover, student perceptions may also vary from discipline to discipline (Hasan et al., 2024). Exploring student perceptions in a particular educational context,

such as engineering education for this research, may help integrate AI to facilitate technology-oriented learning effectively.

1.1 Personal Perspective

As a student, during my undergraduate final year, I became aware of artificial intelligence, but all I knew about artificial intelligence was ChatGPT, which I thought was artificial intelligence, but later realized that ChatGPT is a type of artificial intelligence and there are many others. After my bachelor's degree I enrolled in a master of technical education with a specialization in electrical and electronic engineering. During our first semester we took a course in educational research methodology, and we were assigned to submit a research proposal. I looked into the current research trends and found out that AI is the new trend, and since I have not really engaged with this tool, I became curious. I asked myself, "What is AI?" because when I came to know about ChatGPT, all I heard from friends was, "It is a very good tool; I use it for my studies and assignments." Then I wrote a few research topics and submitted them to my supervisor, then we discussed them, and he finally approved this research topic, and I was motivated to know what this tool is all about in education, and what even made it more exciting for me was knowing that I will interview students about their perspective on AI tools.

I conduct this research to find answers, and I hope my findings will help the teachers and students in using these AI tools effectively.

1.2 Context of this Study

This study was conducted at the Islamic University of Technology (IUT) in Bangladesh, an international institution for education and research operated which is funded by the Organization of Islamic Cooperation (OIC). IUT is one of the universities under the Organization of Islamic Cooperation (OIC), located in Board bazar, Gazipur, Bangladesh, and is internationally recognized for providing high-quality education in engineering, science, and technical disciplines to students from OIC member states. It has a multi-cultural environment with students from different member state from across Asia, Africa, and the Middle East. As a technologically oriented institution with a strong emphasis on engineering and applied sciences, IUT has integrated various forms of digital technologies into its teaching and learning activities. However, the formal integration and adoption of artificial intelligence (AI) in pedagogy are still at a developing stage, similar to many institutions

in the Global. The university's academic culture is shaped by Islamic values such as ethical responsibility, collective learning, and respect for knowledge, which coexist with a progressive commitment to technological innovation. This intersection between faith-based values and modern scientific advancement creates a distinctive environment for exploring how students interpret and engage with emerging technologies like AI. Thus, IUT provides an ideal context for examining engineering students' perceptions of AI in higher education, offering insights that are both contextually grounded and globally relevant.

This intersection of religious ethics and technological advancement shapes how students interpret and engage with AI tools. The engineering environment supports experimental work and fast results yet Islamic principles require responsible technology application and full responsibility and ethical technology assessment. Students develop their opinions about AI through technical knowledge and moral beliefs and values because they understand worldwide technological progress and religious duties. This contextual blend makes IUT ideal for exploring this study.

1.3 Problem Statement

With the rapid progress of artificial intelligence and its growing applications in education especially within higher education we have entered a new era of teaching and learning. These technologies are steadily being incorporated into all areas of education system including teaching, learning, and administrative systems, creating possibilities for individualization, enhancement, and creativity. Nevertheless, the growing use of AI in higher education as a tool for improving educational results, has a number of important issues concerning students. As their teachers and institutions engage with new technologies like adaptive learning systems, virtual teaching assistants, the role and reactions of the students have not been well studied (Sajja et al., 2025).

It is therefore essential to examine students' perceptions of AI, this is because these perceptions will determine the students' participation, and acceptance of such tools. The current research literature has mainly emphasized the technical and pedagogical advantages of AI with little attention given to qualitative aspects such as students' experiences and perceptions (Yue et al., 2022). In addition, the diverse nature of students in tertiary institutions in regards to their learning styles, experiences and exposure to technology makes it difficult for the students to have a similar perception on the use of artificial intelligent technologies.

A gap in the literature remains, due to the lack of detailed insights about students' perceptions and experiences of AI tools. As education systems pursue a digital transformation across the globe, with AI leading the epoch of future academic practices, this gap is a major concern (Pedro et al., 2019). Without an understanding of students' perspectives, the adoption of AI technologies will likely dominate the intended educational benefits leading to solutions that may not align with their needs, expectations, or concerns (Han et al., 2025).

If the ways in which students interpret and engage with AI in higher education remain underexplored, several issues may arise rooted in findings from empirical literature. First, academic integrity gaps can emerge, as students may use AI unethically or may engage in undeclared AI-aided work, leading to plagiarism and unintended misconduct (Lund et al., 2025). Students may rely on AI tools for their academics without considering the implications, which may diminish their creative thinking or cognitive autonomy (Lin & Chen, 2024). Concerns over bias, data privacy, and fairness also go unexamined when student trust and ethical expectations are not investigated (Chan & Hu, 2023). Finally, without the student voice, institutional policies may lack relevance and efficacy: research emphasizes the importance of co creating AI policy with learners to ensure clarity, guidance, and alignment with student needs (Johnston et al., 2024).

his study seeks to fill a gap in the literature by using a phenomenographic approach to examine the diverse ways in which students experience and understand AI in higher education. By identifying and analyzing these variations, the research aims to provide a detailed insight into the factors shaping students' perceptions, thereby supporting the development of AI-driven educational practices that are effective, inclusive, and responsive to learners' needs.

1.4 Research Aims and Objectives

This study is designed to offer a deeper and more structured understanding of the ways in which students interact with and perceive AI technologies. The research seeks to accomplish the objectives below.

1.4.1 Specific Objectives

1. To explore how engineering students perceive and experience the use of AI-driven tools and technologies in higher education.
2. To determine the variations of understanding in the using AI across gender, and background.

1.4.2 Research Questions

Our research questions were developed to examine engineering students' perceptions of AI, and using such technologies in higher institution, as they fulfilled the following research objectives.

1. What are engineering students' perceptions and experiences with AI-driven tools and technologies for their leaning?
2. How do the understandings of the use of AI tools vary across gender, and student type?

1.5 Significance of the Study

This study is relevant in various ways as it explored how engineering students experience and interact with artificial intelligence (AI) in their learning for their academic benefits through a phenomenographic lens. Firstly, it contributes to the literature by exploring the varied perspectives and experiences of students regarding how AI tools are incorporated into their academic activities. In today's digital era, AI technologies are increasingly utilized to enhance teaching and learning. Students can leverage these tools to complete academic tasks and acquire new knowledge.

The findings will provide significant insights into how students engage and experience usefulness, challenges, and ethical concern of AI usage in improving their learning experiences. Such details are crucial for teachers, administration, curriculum designers, and policymakers who are progressively integrating AI tools into the learning environment.

1.6 Thesis Outline

The structure of this study is designed to guide the reader through its key components. It starts with a review of the relevant literature, then describes the research methodology employed. The next section presents and interprets the study's findings, followed by a discussion of the results, their implications, the study's limitations, and suggestions for future research directions.

Chapter 1 introduces the study by outlining its background, aims, research questions, and overall significance.

Chapter 2 reviews key literature related to artificial intelligence in education, learners' perceptions, and phenomenographic research. It also identifies existing gaps that this study seeks to address.

Chapter 3 describes the methodological framework adopted for the research, such as phenomenographic approach, the process of participant selection, and methods of data collection

such as interviews. It also outlines the procedures for data analysis and discusses the ethical considerations observed throughout the study.

Chapter 4: Here, the data obtain from participants interview are presented and analyzed. The different categories of student perceptions are described and interpreted based on the phenomenographic methodology.

Chapter 5: Discusses how the findings are interpreted in light of prior. It demonstrates how students perceive and interact for their learning.

Chapter 6: provide the research contributions, outlines limitations, and provides recommendations.

Chapter 2 Literature Review

This chapter reviews the literature related to artificial intelligence in educational settings, with a particular emphasis on Generative AI (GAI), university students' perceptions, and the research gaps that this study seeks to address.

2.0 Artificial Intelligence (AI)

The definition of Artificial Intelligence (AI) varies across the literature. Minsky (1990) describes AI as machines that can solve tasks that require human cognitive abilities. With its many applications, defining AI precisely remains challenging. However, a widely accepted description frames AI as the capability of computers or automated systems to perform advanced cognitive tasks, including reasoning, inference, knowledge generalization, and learning from previous experiences qualities that are usually associated with human thinking (Keles & Aydin, 2021). Artificial intelligence (AI) is defined as machines with various processing powers and the ability to think like humans, which enhances interaction between humans and machines (Donnell et al., 2024). According to (Shabbir & Anwer, 2018), Artificial Intelligence involves scientific and technical strategies that replicate human cognitive abilities, empowering machines to execute tasks that were traditionally the domain of humans. AI systems now demonstrate capabilities in human reasoning, decision-making, and problem-solving. Artificial Intelligence has found applications across numerous domains, with education being one of the important areas. An AI in learning is a new type of educational technology that facilitates learning anytime and anywhere (Wang et al., 2021). In computer science, artificial intelligence is often described as a technology that employs deep learning models trained on large and diverse datasets. These models transform inputs, such as prompts, into outputs that closely resemble human-generated responses (Marrone et al., 2022).

2.1 Generative Artificial Intelligence (GAI)

Generative artificial intelligence (AI) refers to a group of computational systems capable of creating original outputs such as written text, images, and programming code by recognizing and reproducing patterns found in extensive data collections (Feuerriegel et al., 2024).

Table 2.1 Definition of Generative AI

Author(s), Year	Definition of Generative AI
(Feuerriegel et al., 2023)	GAI is described as methods that learn from existing data to generate novel outputs
(Sengar et al., 2024)	GAI as a shift toward models that create content under both supervised and unsupervised regimes, enabling applications like language generation and image translation.
(Maity & Deroy, 2024)	Highlight GAI's role in intelligent tutoring—dynamic content, instant feedback, and adaptive pathways.
(Mittal, U., Sai, S., & Chamola, V 2024)	Generative artificial intelligence (GAI) represents a branch of AI that creates new outputs by learning patterns from existing datasets.

In the context of this research artificial intelligence is understood as generative AI applied in educational settings, including platforms like ChatGPT, Gemini, and Bard. Generative AI involves models that create new content ranging from text and images to audio and code by learning from existing data and producing outputs that resemble human creativity. These technologies are increasingly adopted by students and educators to facilitate academic tasks and enhance learning outcomes (Feuerriegel et al., 2024). Unlike traditional AI systems that focus on analysis and classification, generative AI models, such as OpenAI's GPT series or Google's Bard, or Gemini are capable of producing original content in response to user input, making them highly applicable in educational contexts for tasks like writing assistance, summarization, and personalized feedback (Zawacki-Richter et al., 2019). According to (Jijeesh & Sail) generative AI empowers personalized Intelligent Tutoring Systems by enabling dynamic content generation, real-time feedback, and learner-adaptive pathways using Large Language Models. These models are built on advanced deep learning and large language models, to understand context and generate coherent outputs (Alqahtani et al., 2023). Within education, generative AI is seen not just as a tool to enhance instructional content but also as a partner in teaching, supporting students' creativity, critical thinking, and individualized learning (Holmes et al., 2019; Kasneci et al., 2023).

This Study define artificial intelligence as a toolbox for engineering students which allows them to have many pathways in solving problems or in reaching your goals within the specific areas or

studies that they are conducting, personalizing learning and support students to better understand or guide them through to their studies. It can also be defined as software or tools that are used to imitate human behavior because these are machines that have been trained to behave or respond in the same way as human beings would wherein both the human and the software itself can interact, that helps education in providing access for students in studying online.

2.2 Benefit of AI in Higher Education

AI is increasingly integrated into higher education, offering benefits such as personalized learning pathways, adaptive assessment, and administrative efficiency.

Artificial intelligence is perceived and utilized in various ways in higher education, focusing on its benefits in education. AI-based technologies in education include intelligent tutors, automated assessment tools, and adaptive educational systems that help customize the learning experience for the specific needs of every learner (Holmes et al., 2019). These technologies have the goal of making it possible for students with different learning speeds and approaches to be active and fully participate in learning activities. For instance, intelligent tutoring systems provide learners with timely feedback and tailor instruction according to individual performance, much like a personal tutor would (Ali, 2024). AI-based assessment tools in education help minimize bias in evaluations (Zhao, 2023), streamline the grading process through automation, and provide tailored recommendations to enhance learning outcomes. The other system is AI-Powered systems such as Duolingo or Coursera, which use data to track the learners and suggest content based for the learner (Imamguluyev et al., 2024).

According to (Zouhaier, 2023) AI provides various learning styles and, allows educators to pick the right method, and strengthens independent learning. AI is revolutionizing education by providing personalized learning. It analyzes student performance data, identifies areas of struggle, and provides personalized recommendations. AI-powered educational systems adapt learning activities and evaluations to match each learner's unique abilities, fostering engagement and motivation. These systems provide focused feedback that supports the development of metacognitive skills and effective time management. They also design personalized learning pathways that reflect students' preferences, strengths, and learning objectives. By integrating current pedagogical approaches, AI ensures efficient learning and helps students achieve better outcomes. This transformative approach could improve outcomes for all students (Alqahtani et al.,

2023). AI-generated content can improve knowledge retention, engagement, and creativity in education by tailoring teaching activities to individual students' psychological requirements. (Chen et al., 2020) highlight that AI improves learning by customizing materials to suit each student's skills and requirements, while also positively affecting teaching, learning, and administrative functions within higher education.

In higher education, AI is applied to streamline administrative activities, including admissions, financial management, library coordination, budget oversight, and student counseling (Alqahtani et al., 2023; Arowosegbe et al., 2024). It also aids administrators in shaping courses, designing teaching approaches, and implementing academic innovations (Karan & Chakma, 2025).

2.3 Drawbacks and Ethical Concerns of AI in Higher Education

Although AI offers significant benefits in education, it also brings challenges, such as potential threats to data privacy, diminished development of critical thinking skills, and the possibility of making learning overly technology-driven. The implementation of AI should aim to assist and empower students, rather than allowing technology to dominate the educational experience (Otto et al., 2023). However there are students that also, expressed their concerns about the reliance on AI technologies which they think will lower the critical thinking skills and creativity of the students (Aoun, 2017). Some of the students were worried about their personal information being misused (Huang, 2023).

Table 2.2 Summary of Benefits and Drawbacks of AI

Benefits	Drawbacks
AI provides various learning styles	Data privacy
It analyzes student performance data, identifies areas of struggle, and provides personalized recommendations	Decrease in critical thinking
AI tools create adaptive learning systems	Risk of dehumanization in learning
AI provides targeted feedback, fostering metacognitive skill development and time management skills	reliance on AI technologies

2.4 Contextual Differences in AI Implementation

AI adoption varies significantly across educational levels primary, secondary, and higher education levels due to differences in pedagogical priorities, student autonomy, and learning objective.

Furthermore, disparities exist between developed and developing countries, influenced by differences in infrastructure, policy alignment, and access to resources.

At the primary and secondary level, AI is mainly used by teachers in preparing materials rather than engaging students directly with AI tools. AI is most commonly deployed through adaptive learning platforms and interactive tools like augmented reality or intelligent tutors that support foundational skill development and early engagement (Galindo-Domínguez et al., 2024). Higher education distinguishes itself through the implementation of AI in more advanced and sophisticated contexts, such as personalized research support, generative writing aids, and critical-feedback systems, facilitating learner autonomy, academic writing, and creative problem solving (Chan & Hu, 2023; Sajja et al., 2025). Although, this shift brings concerns about academic integrity, overreliance on AI, and ethical complexities that are less prominent at earlier levels (Pitts & Motamedi, 2025). In addition, higher education requires comprehensive support structures and digital literacy to guide effective AI adoption, a need that is comparatively less critical in the K–12 context (Jeilani & Abubakar, 2025). The literature consistently demonstrates AI's evolving sophistication and autonomy as students' progress through educational stages, necessitating tailored integration strategies at each level.

Also, the existing literature demonstrates that the adoption of artificial intelligence within universities varies significantly between developed and developing countries, largely due to differences in infrastructure, policy alignment, and resource availability. In developing nations, transformative impact of AI of AI such as enhancing personalized learning and access, often suffers from lack of internet connectivity, poor digital infrastructure, insufficient awareness among educators and students, and a missing policy frame which are important in AI implementation (Aderibigbe et al., 2023; Chisom¹ et al., 2023; Elhajji et al., 2020). Additionally, socio-cultural factors and linguistic barriers have influenced these challenges, employing adaptive AI solutions and capacity building is crucial (Frontiers, 2025). However, in developing countries higher education institutions possess a more robust infrastructure, clearer guidelines for ethical practice and are institutionally prepared (Jin et al., 2025).

2.5 Islamic University Contexts

Few studies have examined how engineering students' cultural and institutional contexts influence their AI perceptions. Research from Islamic universities in Bangladesh and Indonesia

Boangmanalu and Dahlan (2025) shows that faith-based settings regulate technological hope through moral and ethical principles. Students use Islamic values of honesty and fairness and social responsibility to judge AI implementation while they support its use only when it follows educational and ethical standards. The engineering environment within Islamic universities becomes distinct for AI perception research because it unites practical technological work with ethical examination.

Ziaee (2012) explains that Islamic values including halal/haram and obedience and piety serve as core principles for engineering and AI development so technological semantics needs to include religious-ethical standards. The educational system in Pakistan faces pressure from (Bukhari, 2025) because students demand AI tools to follow amanah (trust) and 'adl (justice) which serve as their main ethical principles. An extended Technology Acceptance Model (TAM) study among Muslim students in Indonesia found that compatibility with religious values significantly affects AI acceptance students reported lower intention to use AI when they felt it might conflict with moral or spiritual norms. Salim and Aditya (2025) document that, although AI literacy and usage are growing in Islamic educational settings, concerns over faith-aligned content, ethical oversight, and teacher preparedness remain major obstacles. Sadatul Kahfi et al. (2025) show that while students appreciate AI's potential for improving efficiency and engagement in Islamic Religious Education, many also express worries that spiritual integrity and moral authenticity could suffer

Across both general and engineering programs, students' perceptions of AI are multidimensional combining enthusiasm for innovation with calls for ethical and pedagogical caution.

2.6 Students' Perceptions of AI in Higher Education

Understanding student perceptions of AI is crucial to evaluating its adoption and effectiveness in higher education.

2.6.1 General student perceptions

The literature shows that students maintain positive opinions about AI tools which improve student engagement and time management and learning results (Ma et al., 2025; Zawacki-Richter et al., 2019). Students value AI technology because it breaks down difficult assignments and delivers fast responses and customized educational spaces which boost their attention and work results (Agrawal et al., 2025; Chan & Hu, 2023; Zhou et al., 2024). AI-based assessment systems receive

high value because they provide formative feedback that enables learners to discover their weaknesses and make immediate self-improvements.

The advantages have not stopped multiple studies from showing ongoing doubts about the situation. Students voice their worries about AI overuse because they believe it endangers both their ability to think critically and their academic honesty (Satria & Saputra, 2025). Studies from (Al Zaidy, 2024) together with (Kumar & Raman, 2022) demonstrate that students understand differently based on how well they know AI and their academic levels and ethical knowledge: students back AI use for educational purposes and administrative tasks yet they oppose its implementation in important evaluation areas because they want human involvement to guarantee fairness and transparency.

Recent institutional surveys reinforce these mixed attitudes. The University of Liverpool conducted research during 2025 which revealed that students know about generative AI but they treat Grammarly as a helpful tool while they reject complete essay generation through AI systems. The research by (Johnston et al., 2024) demonstrates that students support institutional policies with ethical guidelines instead of banning all forms of AI usage. Multiple research studies show that students base their attitude toward AI tools through two main factors which include educational benefits and ethical concerns because they accept AI for better learning outcomes yet worry about its effects on genuine work and creative thinking and personal data protection.

2.6.2 Engineering Students' Perceptions

Several studies have explored student attitudes toward AI tools, highlighting variations based on familiarity, academic ability, and ethical considerations.

Students who study engineering and technology fields develop practical attitudes toward artificial intelligence. Research conducted with computer science and engineering students shows they support AI's ability to enhance design and analysis and problem-solving methods (Jooste et al., 2025; Saúde et al., 2024). The students depend on AI as a reliable mental assistant which speeds up their work and allows them to handle complex data and simulations. Students choose to explore new tools because they want to test them and understand their operation. Students show enthusiasm about AI technology but they maintain doubts about its trustworthiness and possible malicious applications.

Several studies have explored student attitudes toward AI tools, highlighting variations based on familiarity, academic ability, and ethical considerations. Studies by (Bittencourt et al., 2020; Kovalchuk et al., 2025) emphasize that AI offers significant benefits in education, including personalized learning through adaptive platforms, intelligent tutoring systems, automated assessment, and enhanced administrative efficiency to improve teaching and learning. AI tools can help structure learning more effectively; however, they may also shape students' emotional engagement and creative thinking in complex ways (Lin & Chen, 2024).

2.7 Research Gap

Existing literature shows that AI enhances personalization and learning outcomes; however, significant gaps remain, including a lack of longitudinal studies and insufficient research on equity and inclusion (Eling & Ogwal, 2025); AI pedagogy and its comparison with traditional teaching methods has limited research (Fu et al., 2024); and the impact of AI tools on various demographic groups raising equity and inclusion concerns has not been studied enough (Degni, 2025). There are also ethical concerns like bias, privacy, and transparency that go unacknowledged with little to no guidance on the responsible use of AI in education (Mustafa et al., 2024). In addition, there is an overwhelming lack of research on the absence of teacher training and professional development frameworks that AI resources could be integrated into teaching and learning (Eling & Ogwal, 2025; Pedro et al., 2019). Also, only few researches have been conducted on students' perception on in Education (Keles & Aydin, 2021). Filling these gaps poses an inclusive and responsible framework of AI in education covering longitudinal impact, comparative effectiveness, equity, ethics, and teacher preparedness frameworks and students' perception.

This study explores an area that has received limited scholarly attention engineering students' understanding of Generative AI within higher education using a phenomenographic lens. Although the concept of AI literacy is increasingly discussed in educational research, it is still insufficiently addressed in university contexts (Chan & Hu, 2023). While existing studies provides extensive discussion on AI applications in higher education, little attention has been paid to how students' personal perceptions of AI influence their willingness to engage with or adopt these technologies (Karan & Chakma, 2025). (Donnell et al., 2024) emphasize that comprehending AI's role in education requires moving beyond the technological dimension to include learners' viewpoints,

particularly regarding how AI can be integrated into curricula to improve learning and employability outcomes.

Previous investigations have generally examined students' overall attitudes toward AI, but their lived experiences with specific AI-based tools remain insufficiently studied (Chan & Hu, 2023). In this research, students' conceptions of AI are examined through their attitudes, experiences, and the contextual factors such as gender, disciplinary background, age, and year of study that shape these perceptions.

Although research has been conducted to explore how higher education students perceive the potential use of AI, the majority of them were conducted from a quantitative paradigm, adapting a deductive approach based on established theories (Chan & Hu, 2023; Kumar & Raman, 2022; Obenza et al., 2024). In contrast, investigating a new phenomenon, such as the use of AI tools in academia, demands a qualitative paradigm, adapting an inductive approach to gain a deeper understanding of the phenomenon. Despite a few studies exploring students' perceptions of AI using interviews, students' voices were not echoed as those were conducted from a first-order perspective (Antony & Ramnath, 2023).

In order to fill all these voids in the current literature, this study utilized a phenomenographic approach, which capture students' perceptions of AI looking through students' eyes, driven by the following research question: How do university students perceive the use of AI in higher education settings?

Phenomenography approach is a qualitative methodology, used for capturing and understanding students' attitudes and beliefs, which allow them to express their thoughts and feelings in more detail about the use of AI in higher education. This includes their expectation, concerns, and perceptions, how it contributes to educational experience and how easily they can interact and adopt AI tools in their studies. This is explained more in details in chapter 3.

Chapter 3 Methodology

3.0 Introduction

This chapter outlines the methodological approach used in this study to explore students' perceptions of using artificial intelligence in tertiary education. A qualitative research approach, namely Phenomenography was used to investigate students' attitudes and beliefs, allowing them to express their thoughts and feelings in more detail about the use of AI in higher education. This includes their expectations, concerns, and preconceptions; how it contributes to the educational experience; and how easily they can interact with and adopt AI tools in their existing workflows, and it also uncovers the variations in students' understandings and experiences of AI within this context. This chapter also describes a methodical approach to data collection, analysis, and the dimension of variations of students' perceptions.

3.1 Phenomenographic Approach

The phenomenographic approach is a suitable research approach that provides a comprehensive framework for exploring how students perceive the use of AI. As well-established in qualitative research, this method allows participants to express their thoughts and beliefs in depth, capturing their understanding of a particular phenomenon (Marton, 2004), i.e., the use of AI in this research. Originating in educational research, phenomenography is particularly suitable for exploring how individuals make sense of phenomena in their lived world. This approach focuses on the variation in experiences, capturing the collective rather than individual perspectives. By doing so, it aligns with the research aim of identifying and categorizing the diverse ways students conceptualize and engage with AI technologies. This approach not only reveals the collective understanding of students but also informs the development of effective educational strategies and interventions by uncovering their nuanced perspective (Åkerlind et al., 2005). The phenomenographic approach is grounded on a non-dualistic ontological assumption which posits that the subject (the learner) and the phenomenon (AI in Education) co-relate (Åkerlind, 2005). Phenomenography, as outlined by (Marton, 1981) focuses on revealing the key differences in the ways individuals within a group perceive a common experience. The phenomenographic approach defines knowledge as relational, subjective, and is kept in relation with the subject and the investigated (Marton & Booth, 1998). Hence, this methodological approach seeks to explore how students relate to and interpret their experiences with AI, paying particular attention to how these perceptions are shaped by the higher

education environment. The aim of the study is to investigate students' perceptions of using artificial intelligence tools and to produce an outcome space, that is, a schematic encoding of the qualitatively distinct types of description based on student experiences.

3.2 Sample of the Study

The study involved 20 participants, which was conducted at one of the engineering universities in Bangladesh, specifically the Islamic University of Technology (IUT). Participants were selected from four engineering disciplines within the university. There are other departments, but these disciplines were chosen based on their purity as engineering departments and the researchers' ease of access. Table 3.1 showed the distribution of the sample by department. The low contribution of other departments is due to the fact that we started the data collection with focus on EEE students and later decided to include other engineering disciplines. CEE has the lowest participating students because there are no international students in the CEE department.

Table 3.1 Distribution of Study Sample

Departments	Number of students
Electrical and Electronic Engineering EEE	10
Mechanical and Production Engineering MPE	4
Computer Science Engineering CSE	4
Civil and Environmental Engineering CEE	2
Total	20

Note: EEE-Electrical and Electronic Engineering, MPE-Mechanical and Production Engineering, CSE-Computer Science and Engineering, CEE- Civil and Environmental Engineering.

3.3 Sample Size and Sampling Technique

To achieve the objectives of this study, participants were chosen through purposive sampling. This qualitative approach involves deliberately including individuals who hold particular experiences or characteristics that are relevant to the research focus (Lopez & Whitehead, 2013). In this case, students familiar with the use of AI applications in academic learning contexts were invited to take part in the study.

The sample size composed of twenty students who were enrolled in an international university in Bangladesh. Due to its broad student body, this includes both domestic and international students,

which enable us to gather a range of viewpoints on the use of AI in higher education. According to (Åkerlind et al., 2005) 15 to 30 participants is the usual sample size advised by phenomenographic research. Smaller samples are acceptable when the context and breadth of the study demand in-depth investigation (Trigwell, 2000). Twenty participants were considered adequate to provide a rich understanding of the phenomenon while adhering to the time and resource constraints of the study.

The participants consisted of undergraduate students of different engineering disciplines from Electrical and Electronic Engineering, Mechanical and Production Engineering, Computer Science Engineering, and Civil and Environmental Engineering. These include both male and female students ranging from first to fourth year of study. Participants had 1 to 2 years of experience using AI tools for educational activities, ensuring they had meaningful insights into the research topic

The goal of phenomenographic study is to identify the qualitative differences variations in how individuals experience and understand a phenomenon (Martön, 1986). In order to guarantee that participants with a range of backgrounds and experiences were included, the purposive sampling technique was selected. By selecting individuals with varied academic years, gender, and knowledge with AI, the study attempted to capture a wide range of perceptions and enhance the analysis.

Table 3.2 Sample and Their Characteristics

Gender	
Male	10
Female	10
Student Type	
Local	10
International	10
Department	
EEE	10
CEE	2
MPE	4
CSE	4
Year of experience	
1 Year	13
2 Year	7

Because the diversity of participant characteristics enhances the data and makes it easier to detect nuanced perspectives, this sampling technique supports the study's objective of identifying diverse categories of knowledge (Lim, 2025). Table 3.2 highlights the sample and their characteristics.

3.4 Data Collection Method

There are a few data collection methods in phenomenography such as observations, document analysis, focus group and interview (Bruce, 1994). This study utilizes an in-depth semi-structured interview (Bowden, 2000). Participants were purposively selected from students who were experienced in using AI tools for educational purposes from Islamic University of Technology (IUT) in Bangladesh. A consent form was provided to the students who voluntarily participated in the study. See Appendix 11. In phenomenography, capturing a wide variation in the sample is crucial for identifying differences in understanding (see Table 3.2). While a sample size of 15 to 30 is recommended (Åkerlind et al., 2005), smaller sizes can be appropriate depending on the study's context (Trigwell, 2000). Therefore, twenty students from the different Engineering disciplines were considered for this study to provide in-depth insights. A total of 20 participants were interviewed, ensuring a manageable dataset for phenomenographic analysis while allowing for sufficient depth and variation in responses.

It is worth noting that, the interviews were about 30 –40 minutes long and, in all cases, audio-taped with the permission of the participants. The interviews were fully transcribed to guarantee that the data were accurate and adequately detailed.

3.5 Data Collection Instrument

The main data collection instrument method for this study was semi-structured interviews which are generally acknowledged as an appropriate tool for phenomenographic research (Cossham, 2017). While preserving a uniform framework to guarantee that participant replies are comparable, semi-structured interviews provide freedom in examining participants' experiences.

Interview Design: The questions asked in the interviews were open-ended and aimed at capturing the students' views of AI tools and how they interact with them as well as their general perception of AI in the learning processes.

Few of the guiding questions included:

- How would you define artificial intelligence (AI) in the context of higher education?

- In what ways do you think AI tools influence your study habits or learning practices?
- How do you believe AI tools contribute to teaching and learning in higher education?
- What challenges or limitations have you encountered when using AI tools in your academic pursuits?
- Are there any ethical concerns or considerations you associate with the use of AI tools in higher education?

Follow-up and probing questions, such as "Can you elaborate on that?" or "Can you provide an example?", were used to clarify and deepen participants' responses. See Appendix 1.

Semi-structured interviews were selected because they provide a balance between guided questioning and the freedom to explore unexpected themes (Bruce, 1994). Phenomenographic methodology, which aims to document the depth and breadth of participants' perceptions, is consistent with this approach. The interviews made it easier to identify diverse and nuanced perspectives on the application of AI in higher education by letting participants express their ideas in their own words.

3.6 Theoretical and Conceptual Basis for Interview Design

The researchers built their interview questions according to the phenomenographic research framework which studies how people understand and experience different aspects of a particular subject (Åkerlind et al., 2005; Martön, 1986). This research examines how students experience and understand artificial intelligence (AI) tools in higher education environment. The questions aimed to uncover different levels of understanding and personal experiences and attitudes instead of verifying specific predictions.

The initial set of questions about AI definitions and tool examples stems from AI literacy frameworks which (Long & Magerko, 2020) developed in 2020 respectively. These questions aimed to capture participants' understanding of AI concepts which function as educational tools in their learning environment.

The Technology Acceptance Model (TAM) served as the foundation for the second set of questions which examined AI tool adoption through user perceptions of tool advantages and disadvantages and implementation outcomes and system performance (Davis, 1989; Venkatesh & Davis, 2000).

The survey questions helped students share their individual evaluations about AI tools in education and their operational value.

The last group of questions which included study habits and ethical concerns and institutional implications followed the structure of variation theory and phenomenographic outcome space logic according to (Marton & Booth, 1997). The research questions aimed to reveal how students experience artificial intelligence differently depending on their educational background and subject matter and moral understanding because phenomenography aims to find description categories which show how people understand phenomena together.

The recent AI-in-education research by (Chan & Hu, 2023; Zawacki-Richter et al., 2019) supports the inclusion of questions about ethical and future implications because students today show rising anxiety about fairness and privacy and academic integrity. The interview design merged phenomenographic principles with AI literacy and technology acceptance framework insights to achieve theoretical strength and match contemporary empirical research.

3.7 Data Analysis

The theoretical foundation for data analysis in this study is grounded in phenomenography, a qualitative research method that allow participants to express how they perceive or conceptualize a situation. The second-order approach, which stresses participant perceptions and understandings over the researcher's preconceived conceptions, is emphasized by phenomenography, which was developed by (Martön, 1986). Finding qualitatively unique categories of description that capture the range of experiences is the goal of phenomenographic study, but not to measure the frequency of certain responses. Each of these categories offers a distinct perspective on the phenomenon, and taken as a whole, they show the variety of viewpoints present in the sample.

This study ensured that the various ways that students view and interact with AI in higher education were thoroughly investigated. This theoretical framework allowed for the categorization and interpretation of data which enable the identification of significant insights into students' perspectives of the use of AI in their academics. In order to discover the rich and diverse perceptions of students, the data analysis technique integrated practical processes with a strong theoretical base. This theoretical and methodological alignment made the results reliable and pertinent, adding significant knowledge to the fields of technology and education.

The data analysis process for this research employed an iterative and systematic approach to identify the qualitative differences in students' perceptions of artificial intelligence in higher education. Following the guidelines of phenomenographic research, the analysis focused on identifying and categorizing the different ways participants experienced and understood the phenomenon (Orgill, 2012).

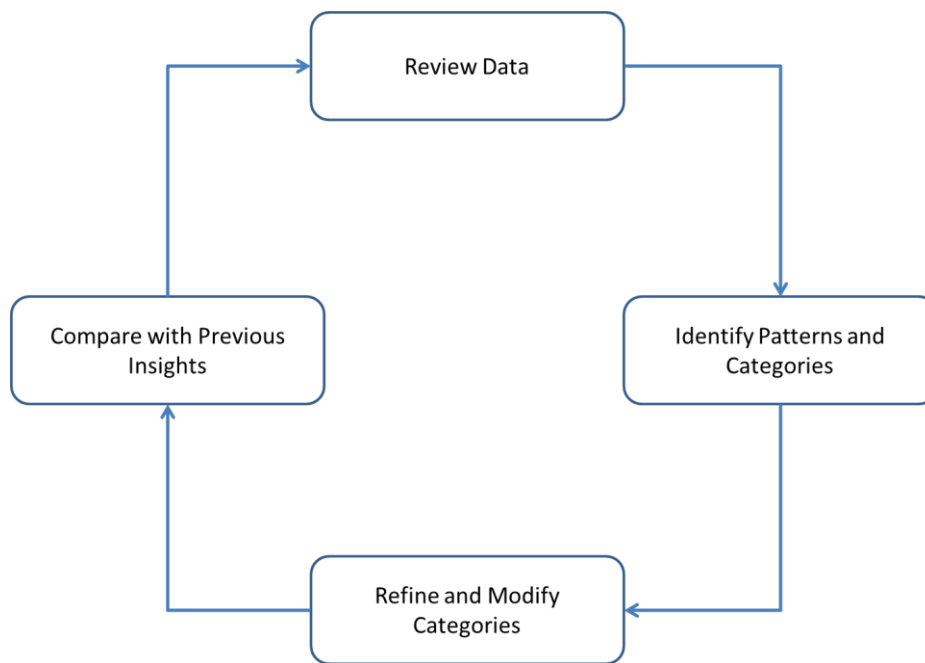


Figure 3.1 Iterative and systematic approach

An iterative approach was adopted by continuously reading the transcript data multiple times to make sense of participants' experiences. Additionally, data were reviewed and specific attention was paid to identifying emerging themes and variations in meaning. Each round of analysis informed the next; improve the understanding step by step, allowing for refinement of the categories as new insights and new patterns emerged. Modified the categories over time based on better understanding. Lastly, new insights were compared with previous ones to make better themes.

The data analysis adhered to an eight-step procedure developed by (Mubarak & Khan, 2022). The data analysis process began with researchers reviewing the interview raw data for clarification by cross-checking audio recordings and transcripts. Next, multiple transcripts were read for familiarization and correction. Then, responses about the conception of AI were accumulated, noting similarities and differences. Individual answers were reduced without distorting their

original meanings, and excerpts with similar meanings were clustered together. The researcher compared these groups to identify discrepancies and ensure cohesion. Categories were then labeled with descriptors that best represented their themes, and these labels were compared with group items for accuracy. Structural relationships among categories were established by describing their unique characteristics and resemblances. To ensure trustworthiness, transcripts were consulted at every analysis stage and all authors provided insights during the data analysis process. Appropriate quotes from the transcripts were used to validate the final categories.

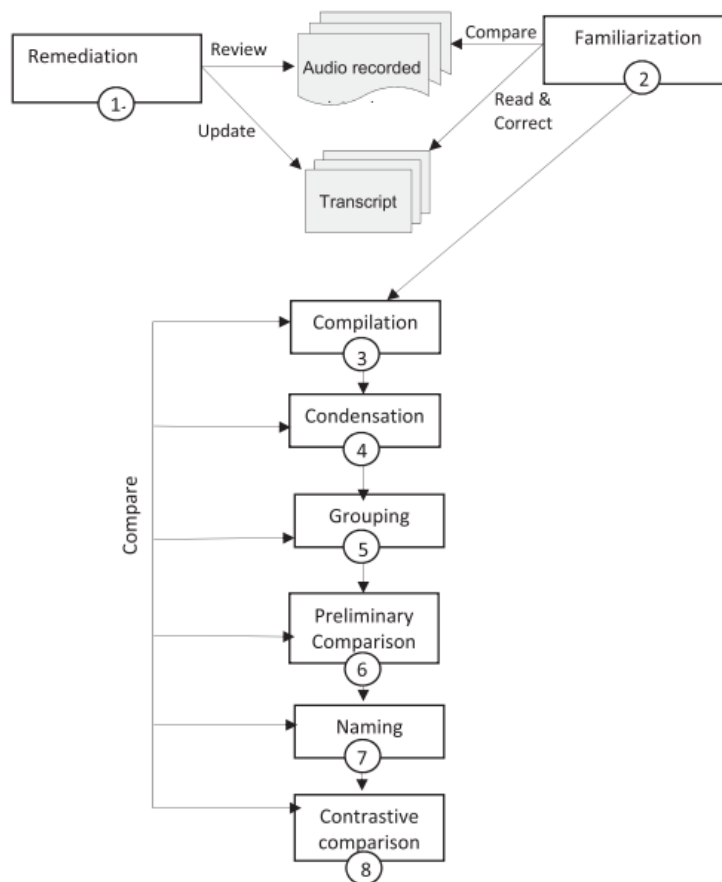


Figure 3.2 data analysis process (adapted from Mubarak & Khan, 2022)

While this study closely followed the eight-step data analysis procedure developed by (Mubarak & Khan, 2022), several contextual modifications were made to enhance trustworthiness and reflexivity in this study. Unlike the original model, which portrayed a linear progression of steps, the interpretation emphasized collaboration, whereby insights were contributed by all authors through-the-whole analysis phase. Transcript data were best searched at each iteration to ensure

consistency in analysis, whereas representative quotes of participants were carefully selected to help validate developing categories. These practices created an iterative and layered analytical process and reinforced the authenticity of the themes in representing actual participant perspectives.

3.7 Validity of the Instrument

According to (Creswell, 2015) validity is defined as the degree to which the research tool utilized for data collecting accurately assesses what it is intended to measure regarding how pertinent study findings are purported to be. The questionnaire of this research study was validated by two faculties who are expert in phenomenography in the department of TVE in IUT. A pilot test of the instrument with 10 EEE students was conducted and their framework was adopted which indicate the validity of the instrument. The instrument was able to answer the research questions, and it was observed that after a pilot test, the instrument was able to provide very rich data, which further confirms the validity of the instrument.

3.8 Ethical Issues

The researcher distributes a consent form to the selected participants and asks their consent to participate in the research interview to adhere to the ethical rules. The interviews were conducted in open spaces such as library, campus space and in the study room. The responders were given an explanation of the study's goals and the significance of the results. The participants were given the freedom to withdraw the study whenever they want, with no consequences or inconvenience. The research findings were disclosed honestly and to avoid plagiarism by citing other people's work and giving credit where credit was due. The collected data, including audio recordings and transcripts of interviews, will be stored in protected digital folders accessible only to the researcher and the supervisor. The data will be stored for a specific period and then deleted permanently. The collected data will be used only for this research, namely students' perceptions of artificial intelligence in higher education, for the purposes of the thesis and publications. And the data will not be shared with third parties or used commercially. The participants were initially informed that their identities would not be disclosed, and they were assured that their responses would remain confidential. Pseudonyms were used in all transcripts, analysis reports, and publications to protect the identities of the participants.

3.9 Pilot Test

The researcher conducted a pilot test of the instrument with 10 students who fulfilled the study's inclusion requirements but were also included in the final sample participants. Pilot test was conducted to assess the interview guide's efficacy, coherence, and clarity. There were slide modifications in phrasing question structure to ensure comprehensibility and relevance. The result of the pilot study was accepted for publication in the Australasian Society for Computers in Learning in Tertiary Education (ASCILITE) conference proceedings 2024 (SCOPUS indexed).

In phenomenographic study data collection and analysis were conducted in a methodical and consistent manner to guarantee reliability while research validity refers to the internal consistency of the data, findings, and study object (Sin, 2010). To test the questions validity and reliability, 10 questions were first submitted to the supervisor for preview and feedback was taken to adjust the questions and after checking the researcher came up with 20 questions which were later validated by two experts in phenomenography in the department of TVE in IUT. Furthermore, by offering detailed explanations of the participants' answers, credibility was strengthened ensuring transparency and rigor in the research findings.

Chapter 4 Analysis and Findings

4.0 Introduction

Five distinct categories were identified that reflect how engineering students perceive the role of AI in five qualitatively different ways. These categories are classified into two broad themes: Positive Conceptions and Negative Conception. Each category is explained in detail, supported by representative quotations from the students.

Table 4.1 Description of each category

Category Name	Description	Focus
Positive		
Category A AI as an essential academic aid	AI is a powerful software, demonstrated by apps such as ChatGPT and Gemini, which is used for diverse academic tasks such as problem solving, paraphrasing, composing content for theses, and time management.	Productivity
Category B AI as a facilitator of personalized learning	AI is a tool that customizes personalized learning by tailoring academic experiences to individual needs, eases academic pressures by simplifying complex concepts for students, fostering a more engaging and effective learning experience.	Personalization
Category C AI as an administrative and teaching tool	AI is a tool used in enhancing administrative duties such as improving feedback system by identifying learning gaps and providing recommendations for improvement, support faculties for content planning and delivery.	Efficiency
Negative		
Category D AI as a critical thinking limiter	AI is tools that serves as a shortcut to learning, promotes academic laziness, and hinder students' ability to analyze and solve problems independently which may cause learners to heavily rely on AI for tasks that require effort, this reliance may reduce critical thinking, cognitive engagement, and creativity.	Cognitive abilities
Category E: AI as an ethical challenge	AI is a tool that AI presents notable ethical challenges in academia, raising concerns about upholding academic integrity and moral values; they can also be exploited for unethical purposes, such as cheating, plagiarism, or bypassing academic protocols. Such misuse undermines fundamental principles of honesty and fairness, calling into question the validity of academic accomplishments.	Unethical practices

4.1 Positive Conceptions

4.1.1 Category A: Engineering Students Perceive the Role of AI as an Essential Academic Aid

Engineering students in category A view artificial intelligence (AI) as an essential academic tool that improves their studies. They recognize AI as powerful software, demonstrated by apps such as ChatGPT and Gemini, which they frequently utilize for diverse academic assignments. The tasks include paraphrasing, composing content for theses, and acquiring new knowledge. Within this category, the role of AI is perceived to be the cornerstone upon which more advanced and nuanced roles of AI are built (i.e., Category B to E), as it highlights the basic utility of AI in academic contexts.

'Artificial intelligence AI is software like ChatGPT, Gemini which we used in our study purposes to paraphrase or write any kinds of content for thesis purpose or to learn anything.' (P4)

'Artificial intelligence is mainly AI tools that we use for different purposes. Like it mainly helps us with designing something or writing something. Yeah, artificial intelligence is basically a software tool that everybody uses for, the purpose of making their work easy.' (P10)

The following themes highlight students' perceptions regarding the role of AI as an Academic aid;

a. Academic content writing and research

Students in this category indicate that they utilized AI (artificial intelligence) tools such as Quillbot, Grammarly and ChatGPT for writing purposes in academic studies. These tools help them write contents, paraphrase, and edit content. Many of those students are using AI to generate coherent and grammatically correct essays, lab reports and research papers. For instance, students use ChatGPT to summarize chapters or improve lab reports, which cuts substantially into the time and work that goes into producing clean, refined papers.

'AI can be used for research. There are lots of research papers you cannot read everything. So, it's nice to have a summarized portion of derived by AI. So that you can read the summary. You will see that if you really need to read it or not.' (P9)

'When it comes to research, there is so much writing needed by the student. One could make use of AI to generate the contents that you may have to write for your literature review, or other parts within your research.' (P11)

b. Solving Academic Problems

Students in this category consider AI for solving complex academic problems such as coding, reading courses and mathematics. Students employ AI tools to detect mistakes in their codes or compute solutions to engineering equations and to understand lecture materials. Additionally, AI offers an initial template for how to approach a problem, learn more about topics and help students fix their challenges and inaccuracies. However, AI is a great tool that we can use to fill in knowledge gaps.

'It helped me for mathematical problems as well as, physics and my major in EEE courses. I took help for the theory courses specifically, because it can simplify the text from what I've read in the book. So, in that way, I can understand this easily. Then I can solve the math, because I knew the theory that this is the way.' (P7)

'I think AI tool is a very great tool for CSE students, especially because it helps us debug the codes that are pretty hard. When we ask a question, it gives us back the answer in a simple way. Sometimes it's complicated, but it's kind of simpler than textbooks and other tools that we use.' (P15)

Students in this category also mention that AI helps them to think about solution of a problem in dimensions. This student said;

'Like, first of all, it helps you to think about a solution in a different way. Like, for example, maybe you were thinking the solution in a way. Then, you put the problem in ChatGPT. It gives you an answer, and you start to think in a different way. Like, yeah, it can be an outside approach to the problem.' (P9)

c. Enhance Academic Performance and Learning Efficiency

Students in this category perceive AI as a digital resource that enhances study outcomes and promotes greater learning efficiency. They acknowledge applications such as ChatGPT, which simplify the learning process by clarifying complex topics and providing accessible explanations. For example, students often rely on AI to clarify challenging concepts and terms, navigate coding issues, summaries academic content, helping them to better understand difficult topics more efficiently. *'Actually, it enhances the learning efficiency, and it also helps the students to do their assignments and researches.'* (P18)

'I think using AI tools can make our learning process better and it can help us like before when you used to go to libraries for learning about something but when we use AI tool this process will become so much time efficient. So, I think the efficiency will be highly increased.' (P5)

Students in this category mentioned that AI assist to promote deeper engagement with their studies and enhances academic performance. Many of the students' credit AI for their improved understanding and higher grades. This student said;

'To me, AI tool is very valuable since I started using AI, as I previously mentioned, my learning approach has been improving and every day, and we are getting new ideas, new knowledge on how to go about AI. And to me, I am using AI based on its purpose. I am not misusing AI, so I am using it for the right purpose and for the right tasks.' (P12)

'Actually, it enhances my learning a lot. Since I have started using AI, I found that my grade becomes better. I improve in my studies more than previously. Also, it helps me to do my researches better, because when you want to do researches, you go to Google, search about the topic, and then the advantages, disadvantages, all this separately but with the AI, you can find all this together in one place. It encourages me to study and saves time as well.' (P13)

d. Time Management

Students in this category highly appreciated AI for its contribution to efficient time management. Time management is important as it helps students to meet assignment deadlines which promote their academic success therefore it is important as an academic aid. Students highlighted that AI delivers instant solutions and explanations minimizes the need for extensive manual research, it also helps them save their time and do more things easily. This improved time management not only reduces stress but also supports a more productive and well-rounded academic experience. *'And it saves your time. You don't have to spend so much time thinking or browsing through books and stuff. Browsing through books is time-consuming.'* (P9)

'They are helping students understand things better, many students are able to meet deadlines more easily. Teachers are working in more flexible hours so they cannot answer all the questions but you can always go to ChatGPT in the middle of the night anytime and prompt for questions

and answers and you will get them instantly other than waiting for the next day to meet the lecturer.’ (P14)

Previously, before AI, I spent a lot of hours studying but now, since AI, I don't spend more hours in studying because I understand topics easily. Like, in less time, I'll understand topics I'm reading.’ (P13)

4.1.2 Category B: Engineering Students Perceive the Role of AI as a Facilitator of Personalized Learning

The perceived foundational role of AI as an essential academic aid (Category A) is further emphasized in Category B, which focuses on how AI adapts to individual needs, thereby enhancing personalized learning experiences. Students in this category view AI as a tool that not only supports routine academic activities but also tailors learning to align with each learner’s specific needs and preferences. This individualized form of instruction enhances understanding and enriches students’ educational engagement, contributing to a more inclusive and effective learning process. While mentioning personalized learning students mention terms like ‘I’, ‘me’.

‘So, using those AI tools, I can actually make those complicated terms, I can tell them to make me understand those complicated terms in a very simpler way.’ (P5)

The following themes highlight students’ perceptions regarding the role of AI as a Facilitator of Personalized Learning.

a. Customization of Personalized Learning and Academic Support

AI tools like ChatGPT and Grammarly have become essential in shaping learning experiences to individual needs. These tools help students to interact with the content in their preferred style and in their own time. For instance, ChatGPT allows students to engage and simplify complex materials, rephrase writings, self-assess and generate tailored study guidelines. Additionally, AI promotes personalized learning setting that match up to each and every student’s unique academic goals. Here are some quotations from students that support the conception.

‘AI basically provides a more personalized learning all students can learn through AI on their own in their houses etc. Sometimes topics I find difficult whenever I go through them, in AI using ChatGPT, it makes it easier for me to understand those topics. Even in robotics things I don't

understand, using these modern technologies like Arduino and others. Whenever I find difficult or challenging things I encounter while using Arduino, when I go through ChatGPT again or Bards, it makes it easy for me to understand that, using codes.' (P13)

b. Alleviation of Academic Pressure

The integration of AI into academic learning activities have profoundly reduces academic pressures such as tight deadlines and difficult assignments. Students highlighted that AI tools simplify and smoothing processes like solving theoretical problems, debugging coding projects and other assignments which helps them to do their assignments independently.

'Personally, I think AI for the students; it's helping us positively, especially when you have a lot of things to do and so many assignments. Most of the time, teachers give assignments which is difficult to combine with six courses, labs, and it will be difficult, and with the exams and quizzes. So, I take help from AI to answer for me. It helps me to eases the burden.' (P3)

Students in this category mentioned that AI reduces their stress of going to colleagues for assistance and also, they consider the benefit of AI, where AI tools produce quick, accessible and relevant information, thus reducing stress and academic pressure.

'Sometimes when you face difficulties while studying, we used to move to our colleagues for assistance. But now I can easily sit in my room and I can absolutely do everything on my own. When I have difficulty, I have someone to consult, which is AI. And if there is a solved example which I did not understand, I can easily paste it and ask AI to explain step by step' (P12)

c. Simplification of Complex Concepts

Students in this category are more concern about how AI helps them to simplify and break down difficult concepts into more understandable way. Engineering students mentioned that tools like ChatGPT clarify complex terms, offer step-by-solution, help in coding and other tasks which enable them to solve problems on their own. Here are some quotations that justify the conception.

'I would say in learning, it makes it easier as I can understand things part by part. In our books, in many cases, the terms used are very complex, which can be explained by using AI easily. So it makes it easier to understand.' (P9)

‘So far with the interaction of AI, there is a lot of improvement from my side. AI will help me on how to go about this particular topic for me to understand. It will break down formulas and explain step by step with AI it can easily explain each symbol and their various SI units.’ (P12)

Students in this category also mention that textbook languages are pretty hard which AI tools helps explain in a simpler manner and provide straightforward answers to their questions enabling them to navigate challenging subjects and improve in their learning.

‘Sometimes textbooks languages are pretty hard, so we go to the AI for a simpler one if we don't find any other tools online that are simpler than the textbooks. So, if we want to know the terms and complicated words from the textbook, AI makes it simpler.’ (P15)

4.1.3 Category C: Engineering Students Perceive the Role of AI as an Administrative and Teaching Tool

In this category, engineering students acknowledge that the role of AI goes beyond providing individual academic assistance (Category A and B) and contributes considerably to the improvement of administrative duties and instructional approaches (Category C). In their view, AI is essential for the modernization of educational systems, as it assists in the transition from traditional practices to more efficient and effective methods. The administrative efficacy of AI tools like Turnitin in academic integrity is emphasized. Additionally, AI helps educators by simplifying complex concepts and facilitating more engaging and understandable teaching methods. Category C is more inclusive than Category A and B, as it encompasses not only the role of AI as the essential tool (Category A) or individual learning tool (Category B), but also includes its role as an administrative and teaching assistant.

‘Yes, again, the integration of AI tools into teaching and learning. Now we are moving away from the olden days to modern ways of teaching, we see a lot of improvement going on. Now we have Turnitin tool which is used by lecturers to check AI contents in our assignments and also by the administration to check plagiarism content of our final thesis.’

The following themes highlight students’ perceptions regarding the role of AI as an Administrative and Teaching Tool

a. Efficient Administrative Tasks

Students in this category identify AI as a tool that improves administrative processes in the academic environment, processes such as converting videos into slides, taking attendance, checking plagiarism, conducting exams, creating lesson plans, and preparing course materials. All these functions of AI reduce administrative work for lecturers, helping them to improve more on their teaching. These are some of the quotations that support the conception.

'Lecturers can conduct exams instead of a lecturer to be taking attendance or exams, marking scripts, like you have a whole lot of students, you can just take the exams through AI tools which will give you the result and also take attendance from the AI tool. I mean that helps to improve and it is more time efficient than the lecturer doing it by himself.' (P1)

'In teaching and learning, I think they can help you to prepare for the lesson plan, as well as the materials, everything. It helps you convert the videos into slides within seconds. So, it's very much helpful for the teachers as well as for the students to understand what the teachers' want, and what they have been taught in the class, also for writing assignments.' (P16)

b. Enhanced Feedback Mechanism

Feedback is our important part of teaching and learning, AI increases the feedback system and quick responses between students and lecturers, promoting an advanced interactive learning environment. Students in this category identify that faculty members use AI tools to check the plagiarism content and writing authenticity from students' work, and provide feedback for improvement. *'Teachers use AI to provide feedback for students to improve their works and resubmit.'* (P3)

'It also helps in the fields of research and the Turnitin tool helps teachers check for plagiarism and ensure that the information that is provided by students is authentic and it meets all the standards and that it does not compromise the integrity of other people that are actually putting a lot of work in their writings and some other people are taking them up for free.' (P14)

'Students can give feedbacks using AI tools, other than lecturers taking feedback from each student, we students can give our response from the comfort of our homes and the lecturers can see automatically what our responses are and take action.' (P1)

c. Efficiency in Curriculum Delivery

Students in this category consider AI as a support to curriculum content delivery by helping the lecturers create simpler and engaging lecture materials. *'Teachers can use it to improve their teaching styles. They can use it to set exam questions.'* (P10) Faculties can employ AI to convert complex technical course content to understandable easy ways, summarize lecture contents, or use visuals or iterative simulations. For example, AI provides students with real life examples in engineering. AI helps in providing diverse learning needs and promotes content delivery method that matches different student learning styles and understanding levels.

'For teaching and learning, especially for teaching like you need to know how things work. AI tools can help teachers in their teaching methodology. They can teach in more simple way unlike normal language in books and for learning.' (P1)

Students in this category highlighted that faculties can make use of AI tools to create more engaging lecture content and materials and notes that will capture attention and engagement with the lecture materials or slides.

'If you use AI for teaching, you can do a lot better in teaching than in the conventional way, writing in the books, and showing a slide that is very boring, but you can use pictures like AI-generated pictures for the same topics you were using earlier, and boring topic, also animations and making slides using AI.' (P7)

d. Faculty Support and Development

Students in this category identify the use of AI beyond assisting with day-to-day tasks, AI also contributes to professional growth of lectures by providing tools that improve their teaching efficiency. For example, lecturers can utilize AI to explore alternative pedagogical approaches, create new ideas for curriculum development, and keep up with enhancement in their areas. Furthermore, AI encourages faculties in improving the overall learning experience. Here are so quotations that support the conception.

'It sometimes helps lecturers to generate the content that they want to have on their classes for their students. Not like using it as the syllabus for the students to use, but as the contents that they

have originally or the course materials that they have based on the institution that they are working on. They can create simpler versions of the contents that they usually give to their students. ' (P11)

Students in this category also mention that AI can help faculties to set questions for exams or quizzes and also evaluate students' capabilities of using AI to solve complex engineering problems.

'Teachers use it to set their questions. Some teachers even use those same AI tools to see which students are copying from each other. They will use it to detect who copied from whom and who did not copy from whom. ' (P3)

'There are some teachers that will give us maybe an open book class work, a complex engineering problem, and then they tell us it's open AI. So, it's also good for the teacher. They want to see how you can use all those tools to answer a question. ' (P3)

4.2 Dimensions of Variations of positive conceptions

Dimensions of variation provide an overview of how each conception varies with respect to a specific dimension. This representation helps understand how each category is distinct from each other. Table shows dimension for each category: Necessity, Accessibility and Convenience, Engagement, and Independence.

Each of the three positive conceptions academic aid, and Personalize Learning, administrative and teaching shows unique variances in the context of artificial intelligence in higher education. The first dimension is Necessity which explains why each conception is needed; it is to help complete academic tasks by assisting with research and problem solving which help students to overcome barriers to academic success in terms of academic aid. While for Personalized Learning emphasizes on catering to individual needs and preferences. AI helps to improve administrative duties and instructional approaches as an Administrative and teaching tool.

Table 4.2 positive conceptions and dimensions

Dimensions	AI as an Academic Aid	AI as a Facilitator of personalize learning	AI as an Administrative tool
Necessity (why each conception is necessary)	To complete academic Task AI is necessary by assisting with research and problem solving which help students to overcome barriers to academic success.	AI is necessary for personalized learning to cater to individual needs and preferences.	AI is necessary for administrative tasks such as teaching, materials, and preparing for classes.
Accessibility and convenience (how each conception tailored accessibility and convenience)	AI provides students with quick accessibility to easy answers, and academic resources at any time.	AI provides convenience and accessibility that allows students to explore various academic tasks on their own and meet assignment deadlines.	AI allows teachers to access time efficient and quality teaching materials and content.
Engagement (how engagement is nurtured in each conception)	Students engage with AI for common academic tasks, like give prompts and commands to answer their questions and challenges during studies or while solving academic problems.	Students engage with AI for personalized learning. They interact with the content personally in a way that suits their learning styles, making the learning process more dynamic and responsive.	Educators engage with AI tools for searching simplified ways of completing administrative tasks.
Independence (how independence is nurtured in each conception)	AI helps students manage their studies independently.	AI empowers students to take charge of their learning process, reducing reliance on educators.	AI provides educators the opportunity to prepare unique and efficient instructional approaches.

'It has improved to some extent because I feel like if there is information that is difficult to find, I will to be motivated to go and do the work easily because I can always draw the information using

the AI tools and work on my assignments easily, meaning they have boosted the productivity and also increased the amount of information that is readily available to the students.’ (P14)

‘Sometimes it’s not possible for a student to do every kind of coding, or creates any kind of paragraphs, but we can learn. Not every time everything is available in the internet, so you go to the artificial intelligence, or ChatGPT, and you type your necessities, and you get feedback, you get an idea of what to read, what to write, and it gives a very descriptive information about the things we want to learn.’ (P7)

‘AI tools can help teachers in their teaching methodology. They can teach in more simple way unlike normal language in books and for learning. For better learning, students can use as well.’ (P6)

The second dimension is Accessibility and Convenience, AI provides students with quick accessibility to easy answers, and academic resources at any time in case of Academic Aid, and while Personalized Learning provides students convenience and accessibility that allows students to explore various academic tasks on their own and meet assignment deadlines. AI allows teachers to access time efficient and quality teaching materials and content.

‘After the introduction of AI tools I can learn easily like I have a big chapter and I can just copy the text and give in ChatGPT and it give me the summary of this chapter so it will give me the summary very easy for my learning.’ (P6)

‘It gives us quick answers for our questions, if let’s say we read from the textbook and then we get a question that is not from the textbook, we just want to know the answer, AI can help us in knowing that answer.’ (P15)

‘AI tool makes the topics simpler for us to learn and even easier. We can even ask it to give us broader than the topic. Let’s say we learn the topic in the class; we want to know more about it. The same way, just like how it makes it a little simple, it makes it a little broad that we can know more about topic’. P15

‘First of all, the teacher who is using AI to make a slide, if it uses animations and pictures generated by AI, and also AI has a way of doing things faster. Obviously, if teacher invests eight hours and makes a boring slide, it’s not going to reach the students the way he wants it. But if he uses AI, he will make much more efficient content that will reach the students in a better way. The

students will learn better, the efforts he's putting in, he will use less time with the efforts he's putting, and it will be more efficient. You know, the whole thing will be more learning efficient.' (P6)

The third dimension is Engagement in Academic Aid, concerns with how students' engage with AI for common academic tasks, like give prompts and commands to answer their questions and challenges during studies or while solving academic problems, while Personalized Learning encourages students to interact with the content personally in a way that suits their learning styles, making the learning process more dynamic and responsive, *'It is helping the students to get information more easily other than having to wait on their lecturers.'* (P14) likewise as administrative and teaching, allow educators engage with AI tools for searching simplified ways of completing administrative tasks. *'Faculties can use AI to like improve their slides, and like generate more content that could make it easier for us to learn certain topics.'* (P9)

'If I wanted to write a code with AI and that code, I wanted to be written in a certain language that I am familiar with. If I was to just say, write for me a code that does this and this and this, and I've given out all the information needed, except that I did not include the specific language that I wanted, it would by default generate in a language that I may not be familiar with, which would be like C, C language. For me, I don't know C language, so when it writes that, I would be like, what is this? I would have to retune, refine tune the question and say, write a code that does such and such using this language.' (P10)

'I ask specific questions and I make sure I have some information of what I are looking for because if you don't know what you are looking for, then you are going to take everything and end up taking wrong things. So to have an idea of what you are looking for, so that when you are provided with the results, you are able to check this and say this is not in the context that I am looking for, this is not in my particular field, and this is maybe not properly structured.' (P14)

'I think one of the advantages of the AI software is where you can make the AI read the article for you. It helps me so much in reading more, because sometimes reading a lot will hurt your eyes. Sometimes I want to do something besides listening, so you can listen to the academic papers through it. Also, it can help you, as I said before, getting different information.' (P16)

The fourth dimension is Independence, is nurtured in Academic Aid to helps students manage their studies independently, and Personalized learning empowers students to take charge of their learning process, reducing reliance on educators. AI provides educators the opportunity to prepare unique and efficient instructional approaches as an administrative and teaching tool.

'Previously I used to do my assignments by myself sometimes, but when I cannot, I try to get help from other people; I used to go to websites, which helped me to find the results, like Chegg or any other website. Now with AI tools I can study independently I don't have to go to other people most of the times for help.' (P18)

4.3 Outcome Space of Positive Conceptions

The structural relationship between the categories of concepts is represented by the outcome space of phenomenographic research (Marton & Booth, 1997). While the structural component emphasizes the "how" of the concepts, the referential component emphasizes the "what" of the conceptions. More precisely, the structural component explains how the meaning was developed from firsthand experience of the phenomena, whereas the referential component reveals the meaning of the conception. Lastly, the "structure of awareness" develops the structural and referential components of the phenomenon while highlighting the participants' emphasis. Table 5 represents the Outcome Space of the positive conceptions.

The outcome scape of the positive conception following AI as an academic aid identifies its ability to improve academic efficiency and productivity in solving academic works. Students view AI as a tool that helps them to simplify and accelerate time-consuming academic tasks like paraphrasing, composing contents, and checking grammatical errors. *'AI tool helps us to check any kinds of grammatical errors and paraphrase it. I think these kinds of things help us in higher studies.'* (P4)

Table 4.3 The outcome space of positive conception

Category Label	Referential element (what AI Tools are conceived as)	Structural elements (How AI Tools are conceived)	Structure of awareness (Focus)
Essential academic aid	AI is perceived as an academic tool used for improving studies.	• Solving academic assignments • Writing tool • Composing and paraphrasing content • Acquiring new knowledge	The focus on improving academic studies is the distinguishing feature of this conception.
Facilitator of personalized learning	AI is perceived as a tool that adapts to individual needs.	• Personalized learning tool • Adapting to individual learning preferences and styles • Eases study burdens	The focus on how it adapts to individual needs is the distinguishing feature of this conception.
Administrative and teaching tool	AI is view as means to improve administrative tasks and support teaching activities.	• enhancement of educational system • Grading • Tackling attendance • Lesson planning • Content generation	There focus was on how AI enhances teaching and administrative duties.

By managing all these processes, AI reduces students' stress and improves them in their academic students. Additionally, AI showcase huge resource hub, offering students quick access to vast number information and materials which may take time to search for it, thereby making research faster and more thorough. Its ability to provide reliable and consistent accurate results has established AI as a trusted aid for a wide range of academic activities.

'So before, I had to take two or three days to complete a lab report. Literally 2 or 3 days because each and every line I had to check whether there is a mistake. So after checking those things I actually write those things in my own ways and then to show that in a good way, I gave this thing

to ChatGPT to make the paraphrase. So, these things actually make my lab reports or anything very presentable.’ (P4)

‘Students can use AI tools for their practical assignment. Sometimes, a teacher gives you an assignment, you do have a basic concept of what you are asked about, that content, and you really don't know how to practically do the things that are required by the teacher. And so, making use of AI's, you could basically generate, or you could ask the AI to generate for you, the answers that are required by the teachers, in the most basic way that you yourself as a student could understand, and the teacher could possibly accept.’ (P11)

‘There are changes like when doing assignments, I can like get hints and paraphrase my writing, and paraphrase like content from a book to understand it easily.’ (P8)

Artificial intelligence AI as a Facilitator of personalized learning highlighted its capacity to amplify educational experiences and to adapt to individual student needs by presenting precise examples, explanations, and recourses that match with their styles and preferences. This individualized method promotes understanding while reducing the stress associated with conventional learning methods. AI makes sure students’ access support at any time, improving continuous and self-directed learning.

‘So, if I start studying at any moment, I can use the hints from ChatGPT or something like that. So, in that way, I should not get the fear of not knowing anything, especially right before the exam. So especially in those parts, during those times, it helped me study because I knew that I wouldn't be stuck or taking help from my batch mates or teachers or running around like that. I can solve this on my own if I use it smartly.’ (P8)

‘If AI is integrated with the education-based system, then every student will have a personalized studying system. So, two legs in which the AI will tackle that and help him with that.’ (P2)

AI as an administrative and teaching tool highlights its importance in improving teaching efficiency, enhancing educational systems and improving learning experiences. In administration, tasks such as grading, and tracking attendance has been made easy for educators by AI. AI supports educators with instructional activities such as lesson planning, content generation, and simplifying complex topics to make students understand better. *‘In teaching, I think they can help you to*

prepare for the lesson plan.’ (P16) Furthermore, AI enriches education with interactive materials, enabling teachers to address diverse learning styles and keep students engaged and motivated.

‘It enhances the normal system that is being taught now. It helps students with their homework’s and tasks. Teachers can use AI for checking if the students copy from one another or like copy from another AI.’ (P15)

4.4 Negative Conceptions

4.4.1 Category D: Engineering Students Perceive the Role of AI as a Critical Thinking Limiter

In contrast to the previous categories A, B, and C, where students perceived the positive impact of AI, engineering students in category D raised concerns about an excessive reliance on the technology and highlight how it might limit the growth of critical thinking and problem-solving abilities. Although AI technologies such as ChatGPT offer significant assistance in finishing tasks and understanding technical subjects, there is a drawback to their utilization. Students understand that relying too much on AI can result in a decrease in their ability to be creative and analytical as well as a decreased interest in the content they are studying. Compared to the other three categories, category D is more inclusive of all previous categories since it acts as a warning layer, reminding teachers and students to the possible dangers of relying too heavily on AI tools.

‘Yes, there is obviously many disadvantages. The first disadvantage is that I feel like, whenever there is an assignment, I have to achieve it. I know that. I have my study buddy there. So this is something I cannot actually get this out of my brain.’ (P5)

‘Let’s say, if I am using ChatGPT to solve everything of my questions, then it will inhibit my creative capacity. So, I would basically not think of the questions as much as before, if I am just using ChatGPT to copy the answers. So, I think that’s a disadvantage.’ (P9)

The following themes highlight students’ perceptions regarding the role of AI as a Critical Thinking Limiter.

a. Dependency on AI tools

Students in this category have shown concern about the increasing reliance on AI tools like ChatGPT for academic activities. These tools are frequently used by many students to generate

content, solve problems or explain concepts, thereby reducing the traditional approaches to research and learning. Although AI provides speed and accessibility, this dependency may discourage students from engaging deeply with their studies. Here are some quotations that justify the conception. *'If the student is too reliant on the AI, then he should get a penalty because he is not studying.'* (P15)

'It is very difficult right now to know if the assignments are written through the AI or not through AI. So, AI will make the students more reliable on the AI contents, and maybe they will not do their work as opposed to.' (P16)

b. Reduce in Creative Capacity

Excessive reliance on AI tools could hinder creative thinking and diminish the chance of self-thought and creativity among engineering students. Students highlighted that, instead of critical thinking or exploring self-ideas, they make use of AI generated answers. However this act can limit their critical thinking and creative problem-solving abilities, which are essential in engineering. While AI offers convenience, it may unintentionally prevent students from fully exploring their creative potential. Here are some quotations that support the conception.

'It limits our research abilities, making us not to extend. Too much reliance on AI is also another issue with students, which is bringing a lot of limitations to students because we cannot think now to do other things, except we depend on AI making us lazy.' (P12)

'When we rely on the AI tools too much, it kind of dull our brain, and even makes us rely on it more, so we don't work harder on learning other things.' P15

'Too much reliance on AI reduces your thinking capacity. I would say reduce my thinking capability and mind of exploration, more things like it is being reduced.' (P6)

c. Shortcut to Learning

AI tools mainly serve as shortcut for learning by breaking down complex concepts, words or ideas into understandable simple ones. Even though it helps students manage their time, it often results in narrow understanding of the material. Students acknowledge AI helps them to complete their academic tasks and understand concepts faster, but this quick response method can obstruct deep learning. For example, although AI offers step-by-step solutions, it might not motivate students to

thoroughly engage with the fundamental principles behind the problem. These are some quotations that justify the conception.

'Before, I would basically rely on the content materials that I have and my ability to understand things on my own but with AI I don't have to give so much stress on me breaking down things that I have to understand. So I just use the tools first, and then make use of my brain. This time I use that approach, but before it was the traditional way of breaking down things and understanding.' (P11)

'If I sit, I want to go through my notes, and I think I do not understand. With AI, I can understand easily. I have my textbook also have a soft copy of the book, and I have AI, we interact. Whenever I find something difficult, I will just copy and ask AI for explanation.' (P12)

d. Potential for Academic Laziness

The comfort and efficiency of AI tools accord to the possibilities of diminishing academic accuracy among students. Many students disclose that AI has fostered tranquility, decreasing their drive to dig in deeply into subjects or challenge solving complex problems by themselves. This laziness could reduce the improvement of dedication and determination or qualities that are important for excelling in engineering. These are some phrases that support the conception.

'It makes the students extremely lazy. Like from my own side, like it's really draining me. At times I have something I'm supposed to do, but just the fact that I know I will take it and give ChatGPT and then it answers. I will just go and give ChatGPT. I don't even stress.' (P3)

'There is laziness because you know you can always get the things so you're pushing the deadlines even further and you're taking longer to do the work that would have maybe taken less time but because you know you're going to just go and search and get the information very easily, you're going to delay the work, which is not very good because you have a lot of work to do.' (P14)

e. Reduction in Cognitive Engagement

Students in this category are concerned about the disengagement in cognition. Although AI offers rapid access to information, it may also lessen cognitive engagement by decreasing the need for self-thought and problem solving. Students highlighted that AI often delivers answers without

proper understanding of the given questions. This may lead to decline in active mental involvement could hinder the growth of analytical skills, which are essential for engineering innovation and effective problem-solving. Here are some quotations that justify the conception.

'It is not that 100% efficient. People don't want to think. I mean, if you have a tool, why would you think? That's just human nature.' (P10)

'I would say before when we used to go to the libraries to find something, we used to learn more like not only the topic I'm searching for, I used to learn more about the things because a book when I'm going through a book I'm reading stuffs. Before we used to learn by using our thinking capacity, but now we don't need to learn.' (P6)

'It could create cognitive disabilities for people who solely rely on AI. Sometimes I just don't want to think, I will say, let me just use AI.' (P11)

4.4.2 Category E: Engineering Students Perceive the Role of AI as an Ethical Challenge

In this area, engineering students consider the ethical implications of AI use, particularly in terms of academic integrity and learning authenticity. They emphasize how AI tools can allow quick access to answers, resulting in behaviors such as copying and pasting solutions that undermine actual learning and moral standards. This viewpoint recognizes the dual character of AI: while it aids academic tasks, it also raises substantial ethical concerns. Students recognize that using AI for assignments can be considered cheating because it bypasses the learning process and reduces the development of independent problem-solving skills. Among all categories, this is the most named, since the foundational (Category A), personalized (Category B), and administrative (Category C) and cognitive (Category D) roles of AI, as well as a critical ethical dimension that encompasses all areas of its use (Category E).

The following themes highlight students' perceptions regarding the role of AI as an Ethical Challenge.

a. Concerns Over Academic Integrity and Moral Standard

Students in this category realize that even though AI tools promote learning efficiency, they also raise ethical concerns. Many students are concerned about the impact of AI on academic integrity as it often draws line between academic moral standard and unethical behavior. Furthermore, excessive reliance on AI tools may cause convenience and unethical practices.

'There are some ethical issues, if a teacher gives an assignment. We just go to the AI and take this answer, copy and paste it. So, it's not morally right. And we do not have the answers in we do not know the answers, but just copying pasting so we're not learning.' (P2)

'I think yes. If I use AI to write something it makes it very easier but supposes one of my friends is writing by her own effort. So, I think it is unfair for her because she is giving the effort and I am using AI tools. So, I think this is ethical concern.' (P4)

Students in this category also highlighted that they mostly get penalties for coping directly from AI tools. They also mention due to the amount of information and contents that are readily available by AI tools may undermine the hard works of previous writers. *'Like coping the text directly from ChatGPT it is not a good academic practice and there are many punishments for that, but I just use it for understanding so I never faced any.'* (P6)

'AI tools have made information so readily available that, this sort of undermines the previous work of people in the past decade. it should be fair because if someone did research back then and received a qualification, they actually did a lot of work, considered to you who is doing it right now and then receiving all this and yet somehow, you're going to receive the same qualification as them, that doesn't seem right. The moment someone receives an assignment or something difficult, they're running to AI which is not ethical.' (P14)

b. Misuse of AI for Cheating

Students in this category give concerns about the misuse of AI tools for cheating. Since AI have the capability of generating quick and instant answers or completing entire assignments, some students are persuaded not to put in personal efforts. These behaviors undermine academic integrity and deduce the effort of other students who work hard to meet academic standards

through honest work. Many students raise concerns, while AI facilitates shortcuts to learning it also jeopardize fairness, especially in assessments where originality and a genuine understanding of the material are crucial. Here are some quotations that support the conception.

'Yes, obviously, the first thing is cheating. So, the teachers, when they give us an assignment, most of the students, they don't want do the assignment by themselves, so they just go for ChatGPT, I myself do that sometimes. I go for ChatGPT because I do not want use my brain, it's hard.' (P7)

'AI is cheating efficient also because it's like, you can go and write anything, ask for any information and AI is going create an article or code for you, but that is not ethical. Sometimes you are given an assignment; the assignment wasn't given to ChatGPT where you were supposed to write it. You can take help from ChatGPT, but copy pasting the whole thing, not even putting an effort in writing the assignment, that is unethical and doing a code that is just copy pasted of ChatGPT, which is also unethical. And I'm just saying all this from the perspective of my academics.' (P7)

c. Undermining Learning Authenticity

The widespread use of AI in academia threatens the authenticity of the learning experience. This may hamper their preparedness for the professional world. Students acknowledge that educators do give warning about over replication of AI-driven content. The decline in learning authenticity undermines the fundamental goal of education: cultivating critical thinking and independent problem-solving skills.

'There are some teachers that give assignment and then they say they don't want any plagiarism or all those sorts of things. But students still used this AI tools in a bad way which is not ethical. I just copy and paste the same thing and then I say paraphrase this phrase for this for me. They should not copy the answer and put exactly the same answer that is wrong.' (P18)

'Definitely there can be a lot of learning fraud, you know, malpractices in exams or in research because people can, students or lecturers or professors can use these tools to leverage themselves. They cannot work again'. (P3)

Students in this category considered that over-reliance on AI solutions may open door for students to submit works that does not reflect their true understanding of the subject or assignment. These students said;

'What they will do is to just take whatever that is out there and use AI tools in combination to get the ideas, which in most cases, like for students they cannot even get a grasp of the concept or understand what they are really doing.' (P1)

'So, another thing that is negative is that you don't learn anything. If you don't really think of it, if you don't really study the answer of ChatGPT, then that is very bad for you. Ultimately, you're just doing yourself harm. You're just losing your knowledge and losing time and not gaining anything.' (P7)

d. Challenges in Policy Implementation

The incorporation of AI into education poses considerable challenges in crafting and enforcing effective policies. Academic institutions face difficulties in defining guidelines that allow legitimate use of AI as a learning aid while curbing its ethical challenge. For example, some educators rely on plagiarism detection software, but such tools have limitations.

'Yeah, I think while interacting with any AI tools, we need to still remember the ethical side and you need to maintain. Even when I'm talking with AI, I don't think being rude or like doing something that we wouldn't do in human form or with human, it should be done because like you can do anything with AI and that doesn't have the capability to do anything to you. But I think still maintaining a boundary is important. Also, AI tools we actually don't yet know the security concerns with the AI sharing very personal data. I think I am very careful about it.' (P6)

'They actually give us the pure restrictions that if they find that we have used ChatGPT, they actually give us a penalty. They actually reduce our mark marks as well because they want as the betterment for us. They want the things to come out from our mind.' (P5)

'Since AI is having popularity in education, teaching and learning. The institution should have some guidelines about using AI. For example, setting some rules, you can use AI to get the ideas,

but not copy and paste because you will harm yourself. Because these assignments have been given to you to understand the subject. So, if you don't understand, you just copy and paste. There is no need for the assignments so they should have some rules regarding that. ' (P16)

Students in this category mentioned that due to the quick advancement of AI tools complicates efforts to maintain up-to-date and relevant policies. Students have advocated for comprehensive orientations to promote ethical AI usage, emphasizing that clearer guidelines could help prevent misuse and uphold academic integrity.

'If the institutions see that their student populations are not making use of these things in the best way, they should make orientation programs and tell them the best ways to use it. ' (P11)

'Teachers use software that can dictate if the content is from AI. First, in the institutions, students should be taught how to go about AI and also implementing some of this software's that dictate AI-related content. ' (P12)

4.3 Dimensions of Variations of negative conceptions

Dimensions can be used to characterize the negative perceptions of artificial intelligence in higher education. To demonstrate how each negative perception varies via each dimension, three dimensions of variation Critical thinking limiter, and ethical challenge were used, as shown in Table 4.4.

Table 4.4 Dimensions of variations of negative conceptions

Dimensions	Critical thinking limiter	Ethical challenge
Dependency on AI	Reliance on AI generated solutions may hinder their ability to think critically and solve problems independently.	Incorporating too much and AI content in your academic works violent academic integrity.
Academic Integrity	Academic integrity is associated with Plagiarism and misuse of AI in assignments which may impact student cognition.	AI can facilitate unethical practices in academics such as cheating, misuse, originality and plagiarism which jeopardize academic integrity.
Peer Collaboration	Reduction for need of collaborative learning and mutual problem solving which limits critical thinking.	Due to individualization of works may cause misuse and an unethical use of AI by some group members.

The first dimensions for negative conception are Dependency nurtured as Critical Thinking Limiter, highlights that reliance on AI-generated solutions may hinder their ability to think critically and solve problems independently; while Ethical Challenge indicates that incorporating too much AI content in your academic works violates academic integrity.

‘Too much reliance on AI is also another issue with students, which is bringing a lot of limitations to students because we cannot think now to do other things, except we depend on AI making us lazy.’ (P12)

‘Yes, there are some ethical considerations. Like just copying and pasting AI contents. It's not good. We're not learning. So, it's not fair. Sometimes in the lab, we're just copying and pasting it. So, what did the teachers gives us marks for, we don't deserve that. So this is the ethical concern.’ (P2)

The second dimension is Plagiarism and misuse of AI in assignments may impact student cognition in terms of academic integrity with regards to critical thinking limiter, while for ethical challenge; AI can facilitate unethical practices in academics such as cheating, misuse, originality, and plagiarism.

‘Ethical issues in AI there are certain questions when you ask in AI, another person can get the same response. And similarly, this results in plagiarism.’ (P13)

‘In academic activities most of the writing, they do lack originality because if you had to sit down with a topic and think through it and actually conduct the research that is required, you'd probably get more substantial information than if you just went to a website and got things that have been written by other people, which may not necessarily even be correct.’ (P14)

Finally, the third dimension for negative conception is peer collaboration nurtured in critical thinking limiter fosters reduction for the need of collaborative learning and mutual problem solving; meanwhile, due to the individualization of works, it may cause misuse and an unethical use of AI by some group members as perceived in the ethical challenge.

‘Yeah, using AI, it reduces human interaction. For example, student like myself since I’ve been using AI a lot, some questions are there, instead of asking the teacher for him to explain to me, I would rather ask AI.’ (P13)

4.4 Outcome space of negative conceptions

The Outcome space of negative conceptions is showed in table 7 below through the referential and structural aspects of the phenomenon.

Table 4.5 The outcome space of negative conception

Category Label	Referential element (what AI Tools is conceived as)	Structural elements (How AI Tools is conceived)	Structure of awareness (Focus)
Critical thinking limiter	AI is perceived as a tool that limits critical thinking and problem-solving abilities.	• Excessive reliance on AI tools • Excessive use of AI • Limits creative capacity	The focus on excessive reliance on AI is the distinguishing feature of this conception.
Ethical challenge	AI is perceived as an ethical challenge	• Unethical use of AI • Compromising academic integrity and authenticity • Direct copying and pasting	The focus on unethical implication of AI tools is the distinguishing feature of this conception.

The outcome space of the negative conception indicating AI as a critical thinking limiter has the potential to reduce students’ intellectual growth. Excessive dependence on AI for completing their works and assignments, or problem solving reduces their chance to develop their critical thinking and problem-solving abilities. By catering students with instant and quick solutions, AI discourages the need for self-thoughts and creativity. This behavior of relying on AI diminishes students' capacity to analyze and deeply engage with academic material, ultimately undermining the quality of their learning outcomes. *‘We will be reliant on Ai technology so much that knowledge or reading the books will be less.’ (P2)*

'The major disadvantages I would say is over reliance on the technology itself. So, what this does is to limit our critical thinking and problem-solving ability because we rely on the tools to do everything, for us that are doing engineering, we know mathematics, but someone that is doing mass communication, it does a lot of writing and all. We have these tools that do it for them. So, they will just rely on these tools to do the writing for them. And unlike, you know, in the olden days or before AI People used to sit and think critically and write and publish. So, we rely on it which limits our critical thinking.' (P1)

AI as an ethical challenge emphasizes concerns over its misuse and an unethical use of AI within the students and its effects on the academic integrity. Practices such as directly coping AI-solutions undermine the originality and authenticity of students work, accelerating significant questions about justifying academic standards. Additionally, students acknowledge that unethical use of AI undermines their learning experience and fosters an overreliance on technology for completing tasks dishonestly.

'It can raise ethical issues because if you use this AI tool for your study purposes, but in the context of for example, I have been given an assignment, right? So, what I can do is I can learn these things, which I can understand in the topics that are given in the assignment. But if I copy the whole concept from AI tool to my answer sheet, that is a disadvantage in the perspective of institution and the teachers, not the students, because they did that. So, this is a huge disadvantage. In this way, the AI tool is used, but the student didn't learn anything. He just copied from the AI tools.' (P8)

'Though there are AI checkers like turnitin. And other stuff like that. Still, people bypass through it. And use ChatGPT completely. Somehow that is not ethical.' (P10)

The phenomenographic study methodology was used in the above thorough investigation to look into how university students conceptualize the use of artificial intelligence in higher education. Five qualitatively distinct conceptions of AI were found through the investigation; three of these were seen as beneficial, and two as a challenge. To further emphasize the differences between the categories, dimensions of variation were also provided for every notion. Finally, the outcome spaces illustrate the structural connections between the notions.

4.5 Ways of Characterizing the Use of AI Tools among Participants

Each student in this study used one of the aforementioned methods to characterize AI tools. The students answered semi-structured interview questions regarding AI tools rather than being asked to select from a list of options. As seen in Table 5, several methods of describing AI tools were mentioned. The purpose of these frequencies is not to imply that a student's method of describing AI is "fixed" or that it is a quality of or inherent to the student. The idea that comprehension can be expanded is implied in educational programs. At least some of the students may characterize AI tools differently in other contexts. This is due to their context-dependent knowledge of AI (Dall'Alba, 1998).

Table 4.6 Frequency of ways of characterizing AI tools

Way of characterizing AI tools	Number of responses
a: AI as an academic aid	14
b: AI as a facilitator of personalized learning	10
c: AI as an administrative and teaching tool	9
d: AI as a critical thinking limiter	11
e: AI as an ethical challenge	8

4.6 Relationship Between Ways of Characterizing Artificial Intelligence (AI)

Some of the methods used for characterizing artificial intelligence (AI) reported here are more detailed than others in terms of the aspect of AI they consider. For example, AI as an academic aid from table (5) shows that has the highest number of responses (14), suggesting that students primarily see AI as a supportive tool in their studies. Similarly, the second most mentioned category AI as a critical thinking limiter has (11) responses, indicating a valuable concern that AI may diminish students' ability to think critically. Additionally, the least mentioned category with (8) responses AI as an ethical challenge, implying that while ethical concerns exist, they are not as prominent as AI's perceived benefits. Each of the five conceptions of AI discussed above is handled in a more or less comprehensive manner. As a result, the methods for classifying AI have been arranged according to these fundamental conceptions, meaning that going from (a) to (e) requires going from least to most acknowledge. However, in education setting all of the methods of conceptions discussed above are important. Students in this study were asked to illustrate the

benefits and the challenges associated with artificial intelligence tools in academic settings. They describe AI in various ways in answer to these inquiries. Therefore, these various approaches cannot be viewed as merely supplemental components but rather as distinct ways of defining artificial intelligence.

4.7 Differences Associated with Gender and Type of Student

In this case, gender is linked to not causing some variations in the characteristics of AI. Following the various ways of characterizing AI the responses of the students were analyzed to see if gender and the type of student have any differences in response. Table 6 displays the ways in which male and female students described artificial intelligence in the current study. Regarding the most and least common methods, similarities are apparent. We have seen in table 4.6 that (a) is the most common conception, while (e) is the least conception from students' responses. Comparing both male and female, 40% of female respondents see AI as an academic aid, whereas only 30% of males share this view, showing a significant gender difference in AI reliance for academic purposes. AI as a facilitator of personalized learning was frequently mentioned by males' students more than females' students (30% for males and 20% for females) while (25%) of female students more frequently characterized AI as an administrative and teaching tool than male students (20%), suggesting female students' view AI benefit as administrative and teaching tool more than the male students. However more male respondents (35%) than female respondents (20%) consider AI as a critical thinking limiter, indicating that male students are more aware of AI's cognitive impact. Conversely, 25% of female respondents see AI as an ethical challenge, compared to only 15% of males, showing that female students may perceive AI as a greater ethical concern. According to (Dall'Alba, 1998) it is important to exercise caution when interpreting gender-related differences because of the low frequencies in certain cases. Males and females may have similar or little variations in their views.

Although as seen in table 7 shows that both local and international students' responses are equal (7 for both) describe AI as an academic aid. On the other hand, AI as a facilitator of personalized learning was frequently described by international (6) than local students (4). Local students (4) rate AI as an administrative and teaching tool lower than international students (5), indicating that international students may see AI's broader role in administration and teaching. More local students (6) express concerns about AI reducing critical thinking than international students (5)

but with minimal difference. Additionally, both groups equally each (4) view AI as an ethical challenge, indicating no significant difference in ethical concerns.

Table 4.7 Ways of characterizing AI tools for male and female

Way of characterizing AI tools	Male	Female
a: AI as an academic aid	30% (6/20)	40% (8/20)
b: AI as a facilitator of personalized learning	30% (6/20)	20% (4/20)
c: AI as an administrative and teaching tool	20% (4/20)	25% (5/20)
d: AI as a critical thinking limiter	35% (7/20)	20% (4/20)
e: AI as an ethical challenge	15% (3/20)	25% (5/20)

Table 4.8 Ways of characterizing AI tools for local and international students

Way of characterizing AI tools	Local	International
a: AI as an academic aid	28% (7/25)	28% (7/25)
b: AI as a facilitator of personalized learning	16% (4/25)	24% (6/25)
c: AI as an administrative and teaching tool	16% (4/25)	20% (5/25)
d: AI as a critical thinking limiter	24% (6/25)	20% (5/25)
e: AI as an ethical challenge	16% (4/25)	16% (4/25)

These findings imply that both the local and international students' view of AI has little or no difference. Additionally, there is also some significance differences in number of responses between male and female students but very minimal see in table 4.7.

4.8 Differences in Students' Conceptions Across Gender and Student Type

While the frequency tables (Tables 4.7 and 4.8) provide an overview of gender and background differences in how students characterized AI, a more nuanced interpretation reveals meaningful variations in the ways students conceptualized AI's role in their learning. These differences were explored qualitatively to capture both the depth and context of students' experiences.

4.8.1 Gender based Variation

Female participants often viewed AI as a supportive academic companion, emphasizing how it helps them manage workload and enhance productivity. One female student explained:

‘AI helps me organize my assignments and summarize materials quickly; it’s like having a personal tutor who never gets tired.’ (*P14, Female, CSE*)

These responses show that many female students view AI in a practical and efficiency-focused way, seeing it as a helpful partner that makes studying easier and more organized. In contrast, several male students highlighted critical or cognitive concerns about AI use, particularly its impact on independent thinking. For example:

‘Sometimes I rely too much on ChatGPT; it makes me lazy to think deeply about the topic.’ (*P5, Male, EEE*)

This shows that some male students take a more thoughtful and cautious approach, worrying about how AI might affect their study habits and ability to think critically. A few female participants also raised ethical issues one noted:

‘We students sometimes copy directly AI solutions in our assignments, but I always wonder if that’s honest or fair.’ (*P8, Female, MPE*)

Such comments reflect a stronger moral consciousness, aligning with findings in recent studies that female students often express heightened ethical sensitivity in technology use (Waqar et al., 2025).

4.8.2 Student Type Variation

Comparing local and international students, the overall conceptions were similar, though nuanced differences appeared in focus. International students tended to describe AI as a personalized learning facilitator, as one student remarked:

‘I use AI to learn at my own pace it’s helpful to make me understand topics I don’t understand in class because I don’t understand English too much.’ (*P4, International student, EEE*)

This reflects the adaptive learning value of AI for international students navigating a multilingual academic environment. Conversely, local students more often viewed AI as a critical thinking limiter, expressing concern over dependency:

‘I notice I stop trying to solve problems on my own when I use AI too often, I become more reliant on the AI.’ (*P12, Local CEE*)

These accounts indicate that while both groups appreciate AI’s support, international students frame it as an enabler of autonomy, whereas local students emphasize its cognitive risks.

From a phenomenographic standpoint, such differences do not represent fixed categories but variations in ways of experiencing AI (Åkerlind et al., 2005; Marton & Booth, 1997). The findings illustrate that perceptions are contextually shaped by gendered learning preferences, cultural exposure to technology, and disciplinary expectations.

Chapter 5 Discussion

5.0 Introduction

This chapter discusses the key findings in light of current research and theoretical viewpoints. This discussion aims to provide a deeper understanding of how students perceive artificial intelligence (AI) in higher education by interpreting the findings in the context of the study's goals. This chapter highlights the various ways that students experience and conceptualize AI, which were identified through the use of a phenomenographic approach in this study. The discussion is structured around the categories of conception identified in the data analysis. Each category is rigorously addressed, taking into account both the advantages and challenges of using AI in higher education.

This study explores university students' perceptions of using AI in academic settings. The findings reveal that students perceive the role of AI in five qualitatively distinct ways: a) an essential academic aid, b) a facilitator of personalized learning, c) as an administrative and teaching tool, d) as a critical thinking limiter and e) an ethical challenge. In the first three categories, students see the potential benefits of AI, whereas in the last two categories, students' concerns about the use of AI are highlighted. Students in categories A and B think that utilizing AI tools in their academic pursuits is efficient in terms of time and effort, making it easier and more beneficial for personalized learning, while in category C they identify its use in teaching and administrative works, such as designing lecture materials and providing feedback to lecturers. In contrast, in categories C and D, students perceive that over-dependency on AI may lead to committing unethical consequences and also limit their creativity. The chapter is structured around the three research questions, followed by an interpretation of the outcome space, a connection with existing literature, and implications for theory, practice, and policy. The chapter concludes with limitations of the study, recommendations for future research, and a summary.

5.1 Discussion of Findings

5.1.1 Perceptions of AI in Learning (RQ1)

The results show students view AI in 5 major ways. Positively, they consider AI to be (A) an important academic tool, (B) a medium for individualized learning, and (C) a tool for administrative and instructional support. Conversely, they identified two negative aspects, considering AI (D) a potential limit to critical thinking, and (E) an ethical issue. Category A, which came up the most demonstrates that students see AI mostly as tool to assist them in their academic

work in areas including writing, summarizing, debugging, and solving problems. Category A is supported by the findings of (Leoste et al., 2021), which positions AI as a resource that supports learning, assists people in their academic work, and contributes to their everyday personal lives. Students reinforced the idea of AI as an integration into their everyday experience with academic work by indicating that AI tools allowed them to save time, manage complex assignments, and tasks more efficiently.

Students also viewed AI as a source of individualized learning because it was perceived as adjusting to students' learning needs. They would share how AI explained concepts at the correct level of complexity, simplified their difficulty, allowed them to learn at their own speed. This major category emphasized the favorably adaptive and supporting nature of AI, where students seemed to feel more control over their own learnings and education. The results show consistency with research showing that AI-focused tools can adapt education, give personalized feedback, and support self-directed learning (Cheng et al., 2023; Luckin & Holmes, 2016). (Cheng et al., 2023; Luckin & Holmes, 2016). By framing AI as adaptive and supporting, students saw AI as more than just a tool for savvy efficiency they were also seeing that its flexible and autonomous capabilities harnessed a worthwhile educational journey.

Some students extended their understanding of AI beyond their personal use, recognizing its purpose in supporting teachers and the educational process. They referenced its potential to assist with tasks like creating teaching resources, marking, tracking attendance, and checking for plagiarism. This category (C) demonstrates students' understanding of AI as a systemic educational support that can increase academic efficiencies (Zawacki-Richter et al., 2019) previously documented this view by framing AI as offering support for teaching and for learning analytics. Students' acknowledgment of AI in these respects indicates that they do not only see it as something that is beneficial to the individual learner but as a way to benefit the larger teaching and learning ecosystem.

In contrast, Category D indicates learners' unease that increased dependence on AI may undermine creative, critical or deep learning. Students explained that a sustained dependence on AI tools could lead to "shortcut learning" and less opportunities to engage deeply with the material. Category D align with Mertala et al. (2022) observation that people increasingly externalize tasks to AI-based systems, reflecting a tendency toward convenience and reduced effort. These concerns call for a

careful balance in both utilizing and relying on AI where learners draw on tools and devise strategies that support cognitive engagement rather than act as a replacement for their cognitive engagement.

Likewise, Category E underscores ethical issues like plagiarism, authenticity of work, and questions of fairness. Students identified unregulated or careless use of AI could lead to dishonest practices and that inconsistent institutional policies left unclear what was acceptable. Findings of Category E resonates with argument of (Cotton et al., 2024), that the misuse of AI in educational contexts raises significant ethical dilemmas. Framing AI as an ethical challenge, students exhibited an understanding that embedding AI into learning is not value-neutral, it requires a clear framework, fair application, and the growth of responsible digital practices.

5.1.2 Experiences and Interactions with AI Tools (RQ1)

Students' experiences and engagement with AI tools revealed opportunities and challenges. Many students noted that they used AI in their studies to make studying easier, improve their writing, and clarify complex ideas. This reporting suggests that students are utilizing AI in an adopted and integrated way in their studying habits and practices. These descriptions suggest that AI is not merely a prospective resource, but have surfaced into students' everyday learning, and there is evidence that physical and digital tools have significant implications on higher education experiences (Luckin & Holmes, 2016).

However, not all experiences were positive. Some students reported encountering inaccurate responses or excessive reliance in AI use to solve their academic problems, which highlight the importance of engaging critically with these tools for better understand and an accurate result. *For example, this student quote “sometimes, AI will go out of the context. It will give you a lot of write-ups which you are not interested in and most of the times mathematical solutions from AI are wrong.” (P12) Another student quote “When we rely on the AI tools too much, it kind of dull our brain, and even makes us rely on it more, so we don't work harder on learning other things.” (P15)* which aligns with (Holmes et al., 2019) proposal that AI should supplement human reasoning instead of replace human judgement in education. In addition, while students appreciated AI tools to allow for personalized learning, some students indicated that using AI predominantly poses risk of diminishing opportunities for peer interaction, or lessening the connection with students and lecturers, raising questions about what social dimensions are in their learning. *This student quote*

‘Yeah, using AI, it reduces human interaction. For example, student like myself since I’ve been using AI a lot, some questions are there, instead of asking the teacher for him to explain to me, I would rather ask AI.’ (P13)

5.1.3 Variations Across Gender and Student Type RQ2)

The results showed some minor differences in perceptions in terms of gender and student background. Male and female students showed similar perceptions of AI, as did local and international students. Females framed AI mainly as an academic support while males referred to personalized learning options and limited critical thinking. Local students appeared to discuss AI mainly in terms of personalization while international students mentioned AI more in terms of administration. These differences were minor and inconsequential to the overall finding, suggesting that perceptions of AI appear to go beyond these demographics. This finding reinforces a similar conclusion reached in phenomenographic work highlighting the shared categories of understanding between different groups regardless of origins or backgrounds (Åkerlind, 2005).

5.2 Outcome Space Interpretation

The outcome space demonstrates the range of qualitatively different ways that students actually perceive AI, with both positive and negative categorizations. The referential dimension describes what AI is for students, include either as learning assistant, a personal learning tool, or an administrative function, versus being viewed as a restriction of higher order thinking or the ethical dilemmas that its use may create. The structural dimension demonstrates how student awareness can vary, regarding the focus of their perception: immediate tasks (Category A), learning processes (Category B), their role in the teaching and administrative system (Category C) and risks regarding dependency and misconduct (Categories D and E).

The layered structure demonstrates students' different levels of awareness of AI in terms of use, and these layered perceptions have important educational implications that could only be developed from the phenomenographic perspective. The range from immediate utility to deeper concerns about educational values, integrity and the purpose of education for society demonstrates the relational nature of learning experiences, characterizing the same phenomenon (AI) a qualitatively different way, in phenomenographic terms (Martön, 1986).

5.3 Relationship to Literature

The results align with existing literature in many ways. First, the concept of AI as an academic support resonates with studies on AI in enhanced learning efficiency (Leoste et al., 2021). Second, personalization findings align with adaptive learning research (Chen et al., 2020). Third, category(C) aligns with (Zawacki-Richter et al., 2019) view by framing AI as offering support for teaching and for learning analytics. Fourth, concerns with critical thinking deficits align with critiques in the field of educational technology (Selwyn, 2019). Lastly, ethical questions mirror recent debates on academic integrity in relation to AI (Cotton et al., 2024).

At the same time, this study adds new understandings by situating these perceptions into a single coherent outcome space, illustrating not just what students find but how these perceptions differ in terms of depth and focus. There is limited research examining students' perceptions of AI with a phenomenographic approach; as such, this study offers something distinctive in emphasizing variation as the key aspect of understanding.

Chapter 6 Implications and Recommendations

6.0 Introduction

The findings of this research have multiple implications for university students, teachers, administration, curriculum designers, artificial intelligence tool designers and anyone involved in academics and research.

6.1 Implications

6.1.1 Theoretical Implications

This research follows a phenomenographic research by examining students' perception of the use of AI in higher their learning, illustrating how the same technological phenomenon is experienced in qualitatively different ways. It further validates the importance of phenomenography as a means of measuring variation in the student experience.

6.1.2 Practical Implications

Students may also be encouraged to utilize AI for their academic learning without compromising the academic integrity. The implications for instructors are to facilitate and promote critical engagement with AI tools, allowing for both appropriate efficiency and richness in learning. Educators can develop learning tasks that invite students to lean on AI's strengths but still be engaged in original inquiry and creation.

6.1.3 Policy and Curriculum Implications

The implications for institutions are to develop clear policies regarding the ethical use of AI; this includes guidelines for concerns of plagiarism, fairness, and transparency. Institutions may also undertake a curriculum-wide effort to train on digital literacy and ethically responsible use of AI, thus ensuring that students develop a critical awareness of the technology at the same time they develop utilitarian skill.

6.2 Limitations

Sample size of 20 students was selected from different engineering disciplines, majority of which were electrical and electronic engineering students, this is because we started the data collection with focus on EEE students then later decided to include other engineering departments which lead to the low participation of other engineering disciplines. However, this has no effect on the data as all of them belong to an engineering discipline. We went for such sample size because the

recommended sample size in phenomenographic research is 15 to 30 (Åkerlind et al., 2005). The researcher feels taking more sample size would have given a richer data and insights about the phenomena. Even though the selected participants were experience in using AI but they were not deeply experienced with the tools as majority were using one or two AI tools. Data was collected in one engineering university in Bangladesh but it would have been more beneficial if data were to be collected from various engineering universities in Bangladesh to gain more diverse experiences and perspectives.

The period within which the master's degree has to be completed can be a restriction on the extent of the data collection. Including a more varied and broad sample selection would enhance the understanding of the phenomenon; however, it may not be appropriate within the constraints of this study. Within these confines, however, the final objective of the research is to offer useful and sound conclusions that enhance knowledge about the application of artificial intelligence in the context of higher learning.

6.3 Recommendation for Future Research

Given the wide range of AI tools currently available, future research could focus on narrowing the scope to a single or specific AI tools, thereby enabling a more comprehensive analysis of its role and effectiveness in educational contexts.” Furthermore, examining how students view AI in various academic fields may offer a broader understanding of its impact on tertiary education. Also exploring the phenomena using quantitative studies may give more generalized conclusion. Comparative studies between students and lecturers may reveal differences between the expectations and experiences between these groups.

6.4 Conclusion

This chapter has reviewed engineering students' perceptions of AI in higher education, organized by the research questions, and it reported that students perceive AI both as a legitimate and powerful enabler of learning and as a potential threat to critical thinking and ethics. Overall, the findings of this research emphasize the need for students to be directed toward responsible, balanced, and critical interaction with AI researchers, particularly in university settings.

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APPENDIX 1

Interview Questionnaire

Phenomenographic Questionnaire: Students' Conceptions of AI Tools in Higher Education

1. How would you define artificial intelligence (AI) in the context of higher education?
2. Can you provide examples of AI tools you have used in your study?
3. How do you believe AI tools contribute to teaching and learning in higher education?
4. Do you think if there is any advantages or benefits of integration of AI tools into academic activities?
5. Do you think if there is any disadvantages or benefits of integration of AI tools into academic activities?
6. In what ways do you think AI tools influence your study habits or learning practices?
7. Have you noticed any changes in your approach to studying or completing academic tasks due to the use of AI tools?
8. How valuable do you consider AI tools in enhancing your overall learning experience?
9. Do you believe AI tools have the potential to significantly impact higher education practices?

Phenomenographic Questionnaire: Students' Approaches to the Use of AI Tools in Higher Education

1. How do you use AI tools in your academic purposes?
2. Are there specific strategies or methods you employ when utilizing AI tools for learning purposes?
3. What challenges or limitations have you encountered when using AI tools in your academic pursuits?
4. How do you navigate these challenges to effectively utilize AI tools for learning?
5. Are there any ethical concerns or considerations you associate with the use of AI tools in higher education?
6. How do you think institutions should address ethical issues related to AI implementation?
7. Where do you see the future of AI tools in higher education?
8. What changes or developments would you like to see in the use of AI tools for academic purposes?
9. How has your attitude towards AI tools in higher education developed over time?
10. Is there anything else you would like to share about your experiences or perspectives regarding the use of AI tools in academia?

APPENDIX II

PARTICIPANT CONSENT FORM

Researcher: Jainaba Jaiteh, MScTE Student, Department of Technical and Vocational Education, Islamic University of Technology

Principal Supervisor: Professor Dr. Mahbub Hasan, Department of Technical and Vocational Education, Islamic University of Technology

Thesis Title: Engineering Students' Perceptions of Using Artificial Intelligence Tools in Tertiary Education: A Phenomenographic Study

Consent Statement

1. I understand the general purpose, methods, and requirements of the study.
2. I understand that my participation in this study is voluntary, and I may withdraw or refuse to participate at any time without any negative consequences.
3. I understand that the interview in which I participate will be recorded and transcribed.
4. I understand that the interview will last approximately one (1) hour.
5. I understand that the interview will be conducted individually and in a mutually agreed-upon location.
6. I understand that the data collected will be used for a Master's thesis, academic publications, and/or conference presentations.
7. I understand that my identity will remain anonymous, and a pseudonym will be used in place of my real name.
8. I understand that all information I provide will be treated as strictly confidential.

Participant Details

Name: _____

Study Program: _____ (e.g., BSc in EEE, 3rd year)

Email Address: _____ (e.g., abcd@iut-dhaka.edu)

Consent

Signature of Participant: _____

Date: _____

Thank you for your participation.

Please return the completed form to the researcher.

