



Relationship Between Generative Artificial Intelligence Tools and Conceptual Understanding among Undergraduate Students

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ABSTRACT

This study aimed to examine the relationship between the use of generative Artificial Intelligence (AI) tools and the conceptual understanding of undergraduate students, and to explore the frequency and purposes of AI tool usage among them. A quantitative correlational design was used, collecting survey data from 298 undergraduate students from two public universities; The Islamia University Bahawalpur and The Govt Sadiq College Women University Bahawalpur, Pakistan. The data covered students' AI usage patterns and their self-perceived conceptual understanding. Findings showed moderate to high levels of AI tool usage, primarily for academic support, assignment writing, and clarification of complex topics. A significant positive correlation was observed between AI tool usage frequencies and perceived conceptual understanding. While AI tools such as ChatGPT, Claude, and Gemini have potential to enhance learning, the results highlight risks of superficial engagement and overreliance. Structured AI integration policies in higher education are recommended to ensure meaningful and sustainable learning outcomes and guide teachers how to use Artificial Intelligence tools in the classroom to get students more interested and help them remember what they learn.

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1. Introduction

Generative artificial intelligence (AI) tools have rapidly transformed educational practices by providing on-demand content generation and personalized academic assistance. Technologies such as ChatGPT, Gemini and Claude are now widely used by students for summarizing content, clarifying difficult concepts and preparing assignments (Zawacki-Richter et al., 2019). The use of Generative Artificial Intelligence in education can be viewed, from a pedagogical perspective, as an element of advancing models of technology-enhanced learning, wherein digital technologies are utilized to facilitate personalized, interactive and collaborative learning (Luckin & Holmes, 2016). The cognitive mechanisms via which Artificial Intelligence -generated texts influence conceptual knowledge are, however, inadequately examined (Fedorets et al., 2024). The majority of literature focuses on the technical proficiency and ethical dimensions of Generative Artificial Intelligence systems, whereas comparatively less research addresses their educational and cognitive implications (Zawacki-Richter et al., 2019). The quick use of Artificial Intelligence tools in schools and university level has both pros and cons when it comes to helping students learn and understand (Manduchi et al., 2024). Generative Artificial Intelligence systems like Catgut, DALL·E and other large language models (LLMs) can generate text, graphics and even code that seems like it was written by a person (Feuerriegel et al., 2024). This helps people with jobs that need creativity, analysis and synthesis. More and more college students are using these technologies to help them learn, finish their homework and understand difficult ideas (Alam, 2023). The quick use of Artificial Intelligence tools in schools has both pros and cons when it comes to helping students learn and understand (Manduchi et al., 2024).

However, there is limited empirical evidence on how such tools influence conceptual understanding, a deeper level of learning that involves connecting, applying and evaluating information. This study aims to explore the relationship between the use of generative AI tools and conceptual understanding among undergraduate students.

1.1. Problem Statement

Generative Artificial Intelligence technologies can facilitate the acquisition of information and enhance productivity; however, there is limited real-world evidence on their impact on students' deep learning processes, particularly their understanding of concepts. Most of the research that has been done so far has looked at how students feel about Artificial Intelligence tools, worries about academic honesty, or how they use them in general (Tao & Pérez, 2025). But we still do not know if using generative Artificial Intelligence tools often and on purpose leads to a greater understanding of concepts or just surface-level involvement. This study aims to fill this gap by examining how undergraduate students' use of generative Artificial Intelligence tools affects their understanding of concepts (Daher, Diab, & Rayan, 2023). It also examines how often and for what reasons children use these tools, including to review material, generate new ideas, or solve school-related problems.

1.2. Significance of Research

In today's institutions, where digital technologies, notably Generative Artificial Intelligence tools like Catgut, Google Gemini, and Artificial Intelligence writing aides, are quickly changing how kids learn, this study is critical. The project looked at how using generative Artificial Intelligence affects undergraduate students' understanding of concepts. It was give us a better idea of how Artificial Intelligence tools affect students' capacity to learn and remember academic concepts. Help teachers and schools use Artificial Intelligence responsibly and productively in their teaching. Also help curriculum designers find new tools that help students learn more deeply.

1.3. Objectives of the Study

- To examine the relationship between the use of generative Artificial Intelligence tools and the conceptual understanding of undergraduate students.
- To explore the frequency and purpose of generative Artificial Intelligence tool usage among undergraduate students.

1.4. Research Questions

- What is the relationship between the use of generative Artificial Intelligence tools and students' conceptual understanding?
- How frequently do undergraduate students use generative Artificial Intelligence tools for academic purposes?

2. Literature Review

Conceptual understanding is vital in higher education as it promotes critical thinking, knowledge transfer and problem-solving. While AI tools offer cognitive support, excessive reliance may hinder deeper learning. The rapid growth of artificial intelligence (Artificial Intelligence), particularly in the form of generative Artificial Intelligence tools, is significantly altering the way we learn. Students can use tools like ChatGPT, Bard (formerly Gemini) and GitHub Copilot to write clear text, solve issues, summaries complicated ideas and even pretend to have intellectual conversations (Siam, Gu, & Cheng, 2024). These abilities prompt us to question how these tools are being utilized in college, particularly in relation to students' conceptual understanding. This is a key part of meaningful learning that goes beyond memorization to include deep understanding, critical thinking and the ability to apply knowledge to new situations (Mavrych, Ganguly, & Bolgova, 2025). Theoretical frameworks like Constructivist Learning Theory, Cognitive Load Theory and the Technology Acceptance Model explain how students interact with AI tools and how these tools influence learning outcomes. Prior studies suggest mixed results: some report improved learning efficiency, while others caution against cognitive offloading and academic dishonesty. This study addresses these gaps by focusing on undergraduate usage patterns and their cognitive implications.

2.1. Overview of Generative Artificial Intelligence Tools

Generative Artificial Intelligence is a type of Artificial Intelligence system that makes new content by learning from patterns in vast datasets. These technologies, which are generally

powered by massive language models (LLMs), may produce text, code, graphics and other sorts of content that look like what a person might write (Bilal, Ebert, & Lin, 2025). Generative Artificial Intelligence has become increasingly common in schools over the last few years, particularly among college students who utilize these tools to write, solve problems, conduct research and seek assistance with their studies. ChatGPT, Claude, Gemini and Copilot are some of the most popular generative Artificial Intelligence technologies (Dhivya et al., 2023; Ragmoun & Alfalih, 2024; Wided & Alfalih, 2023).

2.2. Functions and Capabilities of Generative Artificial Intelligence Tools in Academic Settings

Generative Artificial Intelligence technologies have a lot of different capabilities that help with different parts of teaching and learning in school. In higher education, their skills range from content creation to cognitive support, making them essential resources for both students and teachers. These technologies serve multiple purposes, including information sources, writing aides, study companions, coding assistants and research facilitators. When properly integrated into academic practices, generative Artificial Intelligence tools can boost efficiency, engagement and personalized learning (Panda & Kaur, 2024). Artificial Intelligence, especially generative Artificial Intelligence, is increasingly seen as a cognitive tool that can enhance human thinking, reasoning and problem-solving. Cognitive tools help students complete cognitive tasks they couldn't do alone (Rosas & Fernández, 2022). Artificial Intelligence systems can help students focus on higher-order cognitive skills like analysis, synthesis and assessment by offloading lower-level cognitive functions like obtaining information, correcting grammar and organizing ideas (Urgo, 2020). When students describe a complex idea in their own words, ChatGPT encourages reflection and active learning. This method supports constructivist learning theory, which states that knowledge is constructed through interaction with content and tools (Magallanes Palomino et al., 2021).

3. Theoretical Framework

This study is based on three interconnected theoretical frameworks: Constructivist Learning Theory, Cognitive Load Theory (CLT) and the Technology Acceptance Model (TAM), which together provide a foundation for understanding how and why undergraduate students interact with generative Artificial Intelligence tools, as well as how this interaction affects conceptual understanding (Wang, Bian, & Chen, 2024). The integration of generative Artificial Intelligence tools in education also aligns closely with well-established learning theories: Cognitive Load Theory (CLT) and Vygotsky's Zone of Proximal Development (ZPD). Both frameworks provide valuable insights into how Artificial Intelligence tools can be effectively used to support student learning, especially in promoting conceptual understanding and scaffolding complex cognitive tasks (Gasaymeh, Beirat, & Abu Qbeita, 2024). So, Open Artificial Intelligence's ChatGPT is one of the most popular generative Artificial Intelligence tools. It is based on the GPT (Generative Pre-Trained Transformer) architecture and can understand and write language that sounds like it was written by a person. ChatGPT can help students by summarizing academic materials, breaking down hard ideas, making outlines for essays and answering queries about specific subjects. It is popular in both the humanities and STEM sectors because it is useful and easy to get (Kasneji et al., 2023). A cross-analysis of the evaluated articles reveals that generative Artificial Intelligence techniques are frequently employed across disciplines for a range of academic objectives. (Zhang et al., 2023) and Holmes et al. (2022) show that students commonly use tools like ChatGPT and Gemini for content summarization, idea production and clarification of complicated concepts based activities that are directly related to cognitive development (Zhang et al., 2023). Simultaneously, other studies warn against shallow use, such as copying Artificial Intelligence-generated content without reflection, which may impede deep learning. While many academics agree that Artificial Intelligence has the ability to help cognitive functions, the depth of learning appears to be determined by how and why students utilize these tools.

3.1. Research Gap

Although generative artificial intelligence (AI) tools such as ChatGPT, Google Gemini, and Microsoft Copilot are increasingly integrated into higher education, existing research has largely focused on their technical capabilities, ethical concerns, or general attitudes toward AI. Limited empirical work has examined how the use of these tools directly relates to students' conceptual understanding, particularly in the context of undergraduate education. Furthermore, most studies

have been conducted in technologically advanced settings, leaving a lack of evidence from developing countries where digital literacy, access, and academic culture may influence outcomes. This study addresses these gaps by investigating the relationship between AI tool usage and conceptual understanding among undergraduate students in a developing country context, using quantitative measures to establish correlations and group differences.

4. Research Methodology

This study employed a quantitative correlational research design to investigate the relationship between the utilization of generative Artificial Intelligence tools and the conceptual understanding of undergraduate students. The study was non-experimental, concentrating on naturally occurring variables without intervention. The study was non-experimental, concentrating on naturally occurring variables without intervention. We collected data using a questionnaire that we made ourselves and gave out both online and on paper. The study sought to investigate the frequency with which students utilized Artificial Intelligence tools such as ChatGPT, Google Gemini, Grammarly GO, and Quillbot, and whether this usage impacted their comprehension of academic concepts.

4.1. Population

The population included undergraduate students from The Islamia University of Bahawalpur and Government Sadiq College Women University Bahawalpur.

4.2. Sampling

A sample of 298 students was selected using convenience sampling. Data were collected via a structured questionnaire comprising sections on demographics, AI tool usage (frequency and purpose) and a Likert-scale-based conceptual understanding assessment. The reliability of the instrument was confirmed with a Cronbach's alpha of 0.922. SPSS software was used for descriptive statistics, Pearson correlation and t-tests.

4.3. Data Size and Sources

Data were collected from 298 respondents using a structured, self-administered questionnaire. The questionnaire was designed to measure AI tool usage, conceptual understanding, and demographic characteristics. Data were gathered in person during class hours and through online forms to ensure maximum participation.

4.4. Description of Variables

The study employed two main variables along with selected demographic factors:

- **Independent Variable: Generative AI Tool Use**
This variable measures the frequency, purpose, and patterns of students' use of generative AI tools such as ChatGPT, Google Gemini, Microsoft Copilot, GrammarlyGO, and others. It was assessed through a 10-item Likert scale (1 = Never to 5 = Always) covering academic activities such as concept clarification, summarizing content, exam preparation, and assignment writing. Higher scores indicate more frequent AI tool use.
- **Dependent Variable: Conceptual Understanding**
This variable assesses students' self-reported ability to grasp, retain, and apply academic concepts. It was measured through a 10-item Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) addressing clarity of explanation, retention of information, connection with prior knowledge, and independent learning. Higher scores indicate stronger conceptual understanding.
- **Demographic Variables:**
Demographic information was collected to analyze potential differences in AI usage and conceptual understanding based on: Gender, Age, Year of Study, Academic Discipline (Education, Computer Science, etc.) and Internet access for academic purposes.

4.5. Data Analysis and Estimation Methods

Data were analyzed using SPSS. Descriptive statistics (frequencies, means, and standard deviations) were calculated to summarize responses. Pearson correlation analysis was used to determine the strength and direction of the relationship between AI tool usage and conceptual understanding. Independent samples t-tests were conducted to compare mean differences across gender and discipline groups. The level of statistical significance was set at $p < 0.05$.

5. Results

The demographic section of the questionnaire collected essential background information such as age, gender, department, and year of study. This demographic diversity allowed the study to capture variations in the usage and perceptions of generative Artificial Intelligence tools across academic backgrounds. Most participants were in their early undergraduate years, and the gender distribution was predominantly female due to the inclusion of a women-only institution (GSCWU). The data collected were used to analyze patterns of AI tool usage and assess levels of conceptual understanding, providing a well-rounded view of how generative AI influences academic cognition among university students.

5.1. Tables for AI and Conceptual Understanding Study

Table 1: Frequency of AI Tool Use by Purpose

AI Tool Usage Frequency	Understanding Concepts (%)	Assignments (%)	Exam Prep (%)
Never	10.8	11.4	12.8
Rarely	15.5	13.1	15.4
Sometimes	36.5	26.8	26.5
Often	16.9	28.2	21.1
Always	20.3	20.5	24.2

Table 1 presents the percentage distribution of students' responses regarding the frequency of their use of generative AI tools for different academic purposes, including understanding concepts, preparing assignments, and exam preparation. The five-point Likert scale responses range from "Never" to "Always." The highest percentage of students reported using AI tools sometimes and often, indicating moderate to high engagement with AI technologies for academic tasks.

Table 2: Descriptive Statistics of AI Tool Use by Purpose

(Scale: 1 = Never, 5 = Always)

Statement	Mean	Standard Deviation
Understand academic concepts	3.54	1.12
Get instant answers to questions	3.52	1.11
Generate summaries of content	3.68	1.10
Clarify confusing topics	3.55	1.14
Prepare for exams/quizzes	3.71	1.08
Write reports or assignments	3.65	1.05
Prefer AI over textbooks/notes	3.40	1.20
Verify AI-generated information	3.76	1.02
Use AI without teacher guidance	3.46	1.18
Believe AI helps academic success	3.80	1.06

Table 2 provides the mean and standard deviation for students' reported use of AI tools across ten specific academic tasks. These include concept clarification, summarizing content, writing assignments, and verifying AI-generated information. The highest mean score ($M = 3.80$, $SD = 1.06$) was observed for the belief that AI tools contribute to academic success, indicating a generally positive perception of AI's role in learning. The variability in responses is reflected by standard deviation values ranging from 1.02 to 1.20.

Table 3 Correlation between AI Tool Use and Conceptual Understanding

Variable Pair	Pearson r	p-value	Significance
AI Tool Use & Conceptual Understanding	0.62	< .05	Significant

The Pearson correlation coefficient was calculated to examine the relationship between students' use of generative AI tools and their conceptual understanding of academic content. As shown in Table 2, a moderately strong positive correlation was found between AI tool use and conceptual understanding ($r = 0.62$, $p < .05$). This result indicates that students who more frequently used AI tools tended to report higher levels of conceptual understanding. The

correlation is statistically significant at the 0.05 level, suggesting that the observed association is unlikely due to chance. This supports the hypothesis that generative AI tools may play a meaningful role in enhancing students' ability to grasp, retain, and apply complex academic concepts.

Table 4: Independent Samples *t*-test Results

Group Comparison	Mean Difference	<i>t</i> -value	<i>p</i> -value	Significance
Male / Female	0.27	2.34	0.021	Significant

Independent samples *t*-tests were conducted to examine differences in AI tool usage and conceptual understanding across gender. A statistically significant difference was found between male and female students in their use of AI tools and perceived conceptual understanding ($t = 2.34$, $p = 0.021$). The mean difference of 0.27 indicates that male students reported slightly higher engagement and understanding through AI tools compared to female students. Overall findings show that students frequently use AI tools for summarization (46%), assignment writing (48.7%) and concept clarification (42.3%). A significant positive correlation ($r = .62$, $p < .05$) was found between AI usage and conceptual understanding. *t*-test results also revealed gender and departmental variations in usage patterns. Students who used AI tools critically (e.g., verifying content, paraphrasing) reported higher conceptual clarity than those who relied on copy-pasting outputs.

6. Discussion

The findings according to research question one indicate that generative artificial intelligence (AI) tools such as ChatGPT can enhance students' conceptual understanding by providing individualized explanations and clarifications. This aligns with prior research showing that AI-powered platforms can support deeper learning through adaptive feedback and instant clarification of doubts (Liu, Latif, & Zhai, 2025). However, the study also reveals that students frequently rely on these tools for rapid answers, which may lead to superficial comprehension if the information is not critically evaluated—a concern echoed by previous scholars (Darwin et al., 2024). While AI offers valuable insights into complex topics, it lacks the contextual depth and adaptive pedagogical strategies inherent in human instruction (Strielkowski et al., 2025). According to second research question results demonstrate that approximately 60–70% of undergraduate students use generative AI tools at least once a week, with usage frequency varying by field of study and task complexity. This pattern is consistent with recent findings that AI adoption is higher among disciplines involving frequent content creation and problem-solving (Ouyang, Xu, & Cukurova, 2023). Students reported using AI for homework, coursework, and projects, with some engaging daily for writing assistance and conceptual clarification. Others reported occasional use, particularly for challenging assignments. However, concerns about over-reliance, especially during exam preparation, parallel those raised in earlier studies that warned against AI replacing active recall and critical thinking practices (da Silva, 2024). According to third research question the study found that students primarily use generative AI tools to summarize lengthy texts, simplify complex concepts, and clarify difficult themes. These findings corroborate previous research indicating that summarization and rephrasing are among the most common AI-assisted learning activities (Chen & Gong, 2025). Participants also reported using AI for idea generation, translation, and text rewording, as well as for checking and editing academic work uses similarly noted by prior studies (Monika, Divyavarsini, & Suganthan, 2023). In response, universities are increasingly revising their policies to encourage ethical and constructive AI use, ensuring that it serves as a supplementary learning aid rather than a replacement for student effort.

6.1. Conclusion and Implications

In conclusion, this in-depth survey of 298 people shows that Artificial Intelligence tools are now a big component of how people study in the current world. Students use Artificial Intelligence for more than simply rapid responses; they also use it to summarize material, make complex topics easier to understand, and help them learn. A tiny number of students are still doubtful or prefer traditional techniques, but most of them consider Artificial Intelligence as a helpful tool for learning that helps them comprehend things better and feel more confident. The research shows how important it is to teach Artificial Intelligence literacy in schools. Students' attitudes show both excitement and critical awareness, as their average usage score stays between 3.3 and 3.4. They know that Artificial Intelligence can help people learn on their own, organize information, and link new and old knowledge. Notably, ideas regarding Artificial

Intelligence's function in improving academic engagement and deeper understanding show a move toward more individualized, tech-based learning settings. In the end, Artificial Intelligence tools are changing the way people learn in institutions. They provide learners the confidence and independence to learn on their own. As Artificial Intelligence becomes more common in schools, it's important to use it wisely so that it doesn't replace conventional learning, doesn't hurt academic integrity, and helps students grow in all areas. Ongoing conversation and future research will be very important for making Artificial Intelligence a responsible, inclusive, and revolutionary force in education.

6.2. Limitations and Recommendations

The study is limited to two universities and uses self-reported data. Future research should include longitudinal and experimental studies and explore disciplinary differences. Adding qualitative data (e.g., interviews) could deepen understanding of student-AI interaction.

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