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GENERATIVE ARTIFICIAL INTELLIGENCE TOOLS USAGE AND 21ST CENTURY SKILLS AMONG UNIVERSITY STUDENTS IN SINDH, PAKISTAN

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Abstract

This study was conducted to explore the link between the use of Generative Artificial Intelligence (GenAI) tools and 21st century skills, namely problem-solving, creativity, and critical thinking skills of college students in Lahore, Sindh, Pakistan. The type of research design used was quantitative correlational research. Target population of the study were the undergraduate students of all public and private universities of Sindh. Simple random sampling was adopted in selecting a sample of students and valid responses were only analyzed. Information was gathered with a structured questionnaire featuring five points Likert scale; each construct had several items. The instrument assessed the use of GenAI tools, as well as critical thinking, creativity, and problem-solving abilities. Consistency or reliability of instrument was established by Cronbach's alpha, while the value of Cronbach's alpha obtained was 0.8 meaning that the instrument is in a good state. The statistical software and Pearson correlation were used for analysis of data and testing of hypotheses respectively. The results indicated moderate positive correlations among the use of GenAI tools and critical thinking skills and weak but significant positive correlations among GenAI tools usage and creativity and problem-solving abilities. The relationship between the GenAI tools and the 21st century skills of the students is shown to be meaningful and important but relationships did not have equal strengths. Generally, the use of GenAI tools for supporting students' learning to improve their critical engagement, creativity and problem-solving skills is recommended, not to take the place of students' independent thinking. One important finding from the study is that universities should disseminate "structured guidance" to students about using GenAI tools ethically and effectively in order to reap the educational benefits.

Keywords: Generative Artificial Intelligence, Critical Thinking, Creativity, Problem-Solving Skills.

Introduction

The world of higher education has been greatly impacted by the fast-paced development of digital technologies, primarily in the field of teaching, learning and assessment processes (UNESCO, 2023). In the past few years, the use of generative artificial intelligence (GenAI) tools, like ChatGPT and other applications based on large language models (LLMs), has become more pervasive in their academic lives and transformed how students access information, build knowledge, and accomplish their academic responsibilities (Kasneci et al., 2023). The tools are meant to aid the process of generating text, developing ideas and problem-

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solving, which affects student cognitive engagement while learning. The use of artificial intelligence (AI) for educational purposes has been extensively acknowledged as a game-changer for creating new learning ecosystems. Holmes and Tuomi (2022) argue that the use of the AI in educational contexts is changing the educational approach from memorization to adaptive and personalized learning. Likewise, Luckin et al. (2022) highlight the opportunity of AI technologies to improve students' engagement and efficiency in learning, when used appropriately in these contexts. The 21st century education is given priority towards the development of higher order thinking skills in students, such as critical thinking, creativity, problem solving etc., which are crucial for education success and their future employability (21st century education, 2024). In the education context, generative AI could be used as sort of a cognitive assistant to help students examine complex problems and then cook up some new solutions. At the same time, Siemens (2023) warns that AI systems, if used excessively, could diminish critical evaluation and thinking abilities if used ineffectively (Oad et al., 2024).

Empirical research has recently demonstrated that these generative AI tools can support enhancing creativity, as they would allow students to consider other viewpoints and generate a variety of ideas in academic tasks. Zheng et al. (2024) discovered that the use of AI in learning environments offers substantial benefits for creative output and idea generation among students in universities. Furthermore, Wang and Li (2023) found that AI-aided learning systems can positively impact problem-solving efficiency in students by offering well-structured guidance and mechanisms to give feedback to students. The ability to think critically develops as an integral part of the learning process and is a critical skill in its own right. The link between the use of GenAI and CT skills, however, is multifaceted, as it can enhance CT abilities by presenting students with multiple perspectives or diminish it by relying on too much automatic responses (Rudolph et al., 2024; Faheem, Gulab, & Ahmad, 2025). Generative AI application for Higher Education in Pakistan, especially in Sindh, is still in the early stages of development. Students have become more plugged into these technologies, but there has been little empirical research investigating how such technologies impact 21st century skills. This divide calls into question the contribution of GenAI to the critical thinking, creativity and problem-solving abilities of university students in this region. Thus, this research seeks to explore the relationship between the use of generative artificial intelligence tools with 21st century skills like critical thinking and creativity skills with problem solving skills among university students of Sindh, Pakistan. The results will offer significant insights to teachers, curriculum designers, and policy makers about effectively using AI tools in colleges and universities.

Problem Statement

Problem Statement Although the GenAI has quickly entered the realm of education, empirical insights into how GenAI affects students' cognitive skill-building in developing countries are limited. Recent research reveals that students are using GenAI tools for various educational purposes, such as academic writing, idea generation, and solving problems, but the tools' educational impacts are intricate and still emerging (Kasneci et al., 2023; Dwivedi et al., 2024). While studies indicate AI tools can support learning with scaffolding and feedback, and expose students to a variety of viewpoints, others suggest that over-reliance on such tools could diminish independent thinking and critical thinking engagement (Choi et al., 2024; Rudolph et al., 2024). Due to the lack of consistency in studies, there is doubt about how important GenAI is to 21st century skills like critical thinking, creativity, and problem-solving. Moreover, the use of AI technologies is transforming education practices around the world, underscoring the need for understanding the context of learning behaviors of learners and readiness of

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institutions in different parts of the world (UNESCO,2023). The use of AI in educational outreach is relatively early in development, especially in developing countries, and there is little empirical evidence to conclusively demonstrate its effects in developing regions, specifically in South Asia. There is a huge research gap on the use of generative AI tools among university students and the implications for enhancing their cognitive skills in the context of Pakistan, specifically in the province of Sindh.The utilization of generative AI tools among university students and the cognitive growth implications related to it are underestimated and are undocumented in Pakistan, particularly in the province of Sindh. A literature review suggests that many of the studies are conducted within developed contexts, which makes many findings difficult to apply to local educational contexts where digital literacy and access to technology may differ greatly from that found in a developed context, as the academic practices are likely much different. Hence,the need for systematic examination to investigate relationship between use of generative artificial intelligence (GAI) tools and 21st century skills among the students at Sindh universities in Pakistan.

Research Objectives

1. To examine the relationship between generative artificial intelligence tools usage and critical thinking skills among university students in Sindh, Pakistan.
2. To examine the relationship between generative artificial intelligence tools usage and creativity skills among university students in Sindh, Pakistan.
3. To examine the relationship between generative artificial intelligence tools usage and problem-solving skills among university students in Sindh, Pakistan.

Research Questions

1. What is the relationship between generative artificial intelligence tools usage and critical thinking skills among university students in Sindh, Pakistan?
2. What is the relationship between generative artificial intelligence tools usage and creativity skills among university students in Sindh, Pakistan?
3. What is the relationship between generative artificial intelligence tools usage and problem-solving skills among university students in Sindh, Pakistan?

Literature Review

The rise of Generative artificial intelligence (GenAI) in higher education is impacting educational experiences in various ways—student interactions with learning content are changing, so are the ways in which they create learning materials and complete timely tasks. The tools gained widespread relevance with regard to support the cognitive and academic processes in university contexts. New studies suggest that AI-enhanced learning settings have a positive impact on students' cognitive flexibility and creativity. Liu et al. (2023) suggest that AI tools or writing assistants improve students' idea generation and originality in studying activities. Likewise, Kim and Lee (2024) found that generative AI can enhance the efficiency of students in solving problems and lead to the structured approach to problem-solving as well as step-by-step academic support. As a result, Navarro et al. (2023) noted that the use of AI in learning systems also has a positive impact on student critical thinking when the student is actively involving rather than passively viewing AI feedback. The findings indicate the educational effect oriented to GenAI heavily relies on students' interactions with technology. Some studies however warn about over-depending on AI tools. Rabbi, Park and Shin (2024) contend that, in some cases, over-reliance on generative AI can lead to a decrease in the development of independent analytical capabilities, fostering cognitive dependency. This

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suggests that although there are academic advantages to using these tools, there are also potential challenges that can arise in the context of deep learning in their unregulated use.

Theoretical Background of the Study

This study is based directly on the analysis of Constructivist Learning Theory because according to Piaget (1972) and Vygotsky (1978), learning is an active process in which knowledge is created and produced by learners themselves in response to student's interaction with information, experience, learning tools. These tools can be part of a framework known as cognitive support systems, which can be used by students in the context of generative artificial intelligence (GenAI) to explore ideas, organize information, and develop deeper understanding. It is important to emphasize that constructivist theory also emphasizes active mental engagement, suggesting that learning could be lowered if students were to over rely on the outputs produced by AI without showing any criticality. Furthermore, this study is grounded by the 21st Century Skills Framework which underscores the importance of think critically, be creative, communicate, and solve problems in modern education and workplace, which are critical skills to acquire (Trilling & Fadel, 2009; Voogt & Roblin, 2012). If viewed from this angle, the GenAI tools could come in handy to develop these skills by offering access to rich knowledge inputs, as well as idea generation support, but might introduce barriers to independent thinking if used without engaging with analysis.

Conceptual Framework

The conceptual framework of this study is based on the relationship between generative artificial intelligence tools usage and 21st century skills among university students. The independent variable for this study is the generative artificial intelligence tools usage; and the dependent variables are critical thinking skills and creativity skills and problem-solving skills. The framework acknowledges that generative artificial intelligence tools like ChatGPT and Gemini might impact students' thinking and action. Therefore, the study examines how generative AI tools usage is related to students' critical thinking, creativity, and problem-solving abilities.

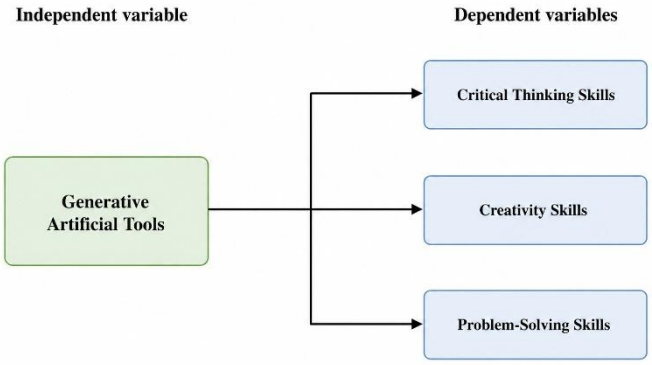

Figure 1

Generative Artificial Intelligence Tools Usage and Critical Thinking Skills

Use and critical thinking skills around G.A.I. products and tools The study reveals that there is growing importance of the GenAI in influencing students' cognition and learning actions in Higher Education, in recent time.In recent time, the study shows the role of GenAI in influencing students' cognition and learning actions in Higher Education is growing. These

tools have also been found to be used in purposeful ways to aid in writing assignments, develop ideas, and enhance academic problem solving, and have contributed to a research interest in how these tools affect higher order thinking skills like critical thinking. The application of AI tools as writing assistants has shown potential to enhance students' analytical involvement and engagement by providing exposure to diverse viewpoints, thereby solidifying critical thinking processes (Grassini, 2023). Likewise, Sallam (2023) provided evidence that the use of generative AI improves learning ways by boosting efficiency and understanding, especially when students actively analyze and adjust AI-generated content rather than passively consuming it. Conversely, there are fears of the cognitive effects of GenAI tools. The use of AI-generated answers could lead to students becoming less independent thinkers due to relying on AI-generated responses, according to Firat (2023). This implies that there is a risk that students could acquire an unhealthy dependence on AI tools without engaging in deep thought and critical analysis. In addition, Chen et al. (2024) note that GenAI tools offer instant aid in the academic field, but they could also foster shallow learning if students are not able to check the outputs generated by the optimization mode. This evidences the danger for deep learning process in higher education. The literature shows a double perspective as a whole. GenAI tools can support students to develop their critical thinking by exposing them to a variety of ideas and scaffolded feedback but can also have the potential to reduce critical thinking and the depth of their analysis. The implementation of these tools to academic learning practices remains a key to the effective implementation.

H_{01}: There is no significant relationship between generative artificial intelligence tools usage and critical thinking skills among university students in Sindh, Pakistan.

Generative Artificial Intelligence Tools Usage and Creativity Thinking Skills

Using and thinking creatively with a Generative Artificial Intelligence Tool.Application and Creativity Skills with Generative Artificial Intelligence Tool. Creative processes in higher education have been greatly changed by the unleashing of recent advancements in Generative Artificial Intelligence (GenAI).The recent breakout Generative Artificial Intelligence (GenAI) developments have profoundly impacted creative processes in higher education, empowering students to produce ideas, brainstorm solutions and create new academic products. Today with increasing use in brainstorming, content writing, and problem-solving these tools have caught the interest of researchers to their impact on students' creativity skills. Research shows that GenAI tools can be valuable to the creative development process, enabling divergent thinking and idea expansion. Using AI learning environments offers a range of benefits to students, including the ability to produce more creative outputs by offering students a way to consider alternative perspectives and generate multiple versions of their original ideas when completing educational tasks. (Zhan & Lu, 2023; Imran et al., 2023). Either way, Wang et al. (2024) found that generative AI systems enhance creative performance in writing and design-related jobs by suggesting ideas and structuring inspiration instantaneously. While there are many advantages to using AI for creative learning, some studies have also identified certain limitations of AI's usage. However, Cope and Kalantzis suggest that if students fall prey to the overreliance of the AI-generated idea instead of fostering their own thought, originality may be compromised. This indicates that, if not expertly nurtured, creativity might move from independent idea generation to the idea generation supported by AI. Furthermore, Zhang et al. (2024) stress that GenAI tools may inspire creativity by requiring a wide range of input, but their impact is significantly rooted in students' critical thinking in absorbing the information generated by the tools. AI-generated text might encourage reliance on passive acceptance of outputs, potentially reducing

creativity; but active engagement with AI can foster greater innovation and originality. Overall, the literature presents a dual perspective. Generative AI tools have the potential to enhance creativity skills by expanding idea generation and supporting innovative thinking; however, their impact may become negative if they replace rather than support students' independent creative processes.

H_{02}: There is no significant relationship between generative artificial intelligence tools usage and creativity skills among university students in Sindh, Pakistan.

Generative Artificial Intelligence Tools Usage and Problem-Solving Thinking Skills

AI tools in higher education are centered on supporting students with higher-order cognitive skills such as reasoning, analysis, and decision making across a variety of academic areas and are referred to as generative-artificial intelligence ("genAI"). These tools help students by offering step-by-step solutions, explanations and alternative ways to approach studying problems, which impacts the process of studying problem-solving. Recent research indicates that GenAI can help students develop skills in problem-solving, such as their capacity to analyze complex problems and consider various solutions. Kim et al. (2024) discovered that using AI-supplemented learning environments helps students solve problems more efficiently by offering guidance in the process of problem-solving and providing feedback adaptation. Likewise, García and Fernández (2023) stated that in the math and analytical subjects, students benefit from generative AI tools that help them gain understanding of how problems are structured and use the right strategy in each instance. But others indicate some drawbacks to using AI tools for problem-solving development. With excessive reliance on AI-generated solutions, Lee & Kim (2023) suggest that students might lack independent thinking skills and avoid the challenge that comes with serious problem understanding. This can contribute to low ability in problem solving skills at a later age. Moreover, Ahmad and Khan (2024) point out that using GenAI tools for quicker problem-solving relies on the students' active participation in the reasoning process. The ability to discus the solutions obtained from AI enhances problem-solving skills, while lacking in critical thinking can stunt thinking abilities. The literature suggest a double-edged sword effect of GenAI tools on problem solving skills. These tools can improve students' analytical skills and help with a structured thought process but this depends on directed and critical use that keeps students actively involved in the problem-solving process.

H_{03}: There is no significant relationship between generative artificial intelligence tools usage and problem-solving skills among university students in Sindh, Pakistan.

Research Methodology

The study was a quantitative research using correlational research design to analyse the relationship between usage of Generative Artificial Intelligence (GenAI) tools with three 21st century skills i.e., critical thinking, creativity and problem-solving skills among the students of universities in Sindh, Pakistan. According to purpose, the study that was conducted is correlational design because the study sought to discover the nature and strength of relationships between variables without having to manipulate the variables. The respondent population comprised students from public and private sector universities of Sindh at undergraduate levels in either colleges of arts or universities. The number of competent and complete responses obtained after data screening was 235 of the 280 students with a simple random sampling technique. The data was taken by a structured questionnaire using a Likert Scale ranging from strongly disagree to strongly agree. It was comprised of 4 constructs (10 items per construct): generative AI tools usage; critical thinking; creativity; problem solving

skills. The questionnaire was gleaned from already validated questionnaires and customized to the local educational context. In order to test the reliability, there was a pilot test run with 30 respondents prior to the main study. Internal consistency of the Cronbach's alpha was generally good for the GenAI tools usage (0.84), critical thinking (0.86), creativity (0.87), problem solving skill (0.85), overall (0.88). The analysis was performed using SPSS software in which the Pearson correlation was used to test the relationship between the variables in line with the aims of the study. A significance level of $p<0.05$ was used for all of the statistical tests. Informed consent, confidentiality, anonymity and voluntary participation ensured ethical considerations.

Table 1: Reliability Analysis of the Instrument (Cronbach's Alpha)

Variable	*No. of Items*	*α*	*Reliability Status*
GenAI Tools Usage	10	0.84	Good
Critical Thinking Skills	10	0.86	Good
Creativity Skills	10	0.87	Good
Problem-Solving Skills	10	0.85	Good
Overall Scale	40	0.88	Good

Data Analysis and Findings

Demographic characteristics of the subjects participated in this study (N = 235) are shown in Table 2. The gender distribution is male-female with a higher proportion of female (n = 133, 56.6%) than male (n = 102, 43.4%) students, which implies a soft representation of the sample for the females. Regarding University type, majority of the respondents were studying at public sector University (n = 140, 59.6%), while a smaller percentage were in private University (n = 95, 40.4%), which shows more participation at public Universities. Regarding year of study, the largest group of respondents was from the 2nd year (n = 74, 31.5%), followed by 1st year students (n = 68, 28.9%), 3rd year students (n = 53, 22.6%), and 4th year students (n = 40, 17.0%). Overall, the demographic breakdown shows a diverse sample of boys and girls, by institutional background and academic level, lending itself for a representative analysis of the usage of generative artificial intelligence tools and 21st century skills of the university students from Sindh, Pakistan.

Table 2: Participants' Demographic Characteristics

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Variable	*Category*	*Frequency (f)*	*Percentage (%)*
Gender	Male	102	43.4
	Female	133	56.6
University Type	Public	140	59.6
	Private	95	40.4
Year of Study	1st Year	68	28.9
	2nd Year	74	31.5
	3rd Year	53	22.6
	4th Year	40	17.0
Total		235	100

Hypothesis Testing

H_{01}: There is no significant relationship between generative artificial intelligence tools usage and critical thinking skills among university students in Sindh, Pakistan.

Pearson correlation was used to analyze the relationship between generative artificial intelligence (GenAI) tools usage and critical thinking skills of University students of Sindh, Pakistan and it is presented in Table 3. The findings suggest that there is a moderate to moderately strong positive correlation between the use of GenAI tools and the ability to think critically ($r = .58$, $p < .05$). The correlation indicates that an increase in the use of GenAI tools is linked to an increase in students' critical thinking skills at universities. The positive relationship suggests that there is a positive association between the two variables. The correlation ($r = .58$) is substantial, suggesting a significant correlation between using GenAI tools and students' critical thinking skills in the targeted context. In addition, the value of p is statistically significant, with p-value< .05 suggesting that the correlation is unlikely to be random, thus supporting the rejection of the null hypothesis (H_{01}). Therefore, it can be concluded that students from universities in the province of Sindh, in Pakistan, critically think highly when using GenAI tools.

Table 3: Pearson Correlation between GenAI Tools Usage and Critical Thinking Skills

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Variables	1	2
GenAI Tools Usage	1	-
Critical Thinking Skills	.58**	1

Note: Pearson correlation (r) is reported. $p < .05$ (significant)

H_{02}: There is no significant relationship between generative artificial intelligence tools usage and creativity skills among university students in Sindh, Pakistan.

Table 4 displays Pearson correlation between the usage of Generative Artificial Intelligence (GenAI) tools and creativity skills among the University students of Sindh, Pakistan. The findings reveal that GenAI tools usage and creativity skills are associated, however the association is weak and only statistically significant at $p < .05$ ($r = .24$). The greater the use of GenAI tools, the more slightly students' creativity skills were linked to it. At the same time, the relationship is relatively weak with only a small proportion of the variance in creativity skills being explained by the extent of usage of the GenAI tools by the university students. The directionality of the relationship is positive, meaning that both variables vary in the same direction, but there is not a strong relationship. If the observed relationship is statistically significant ($p < .05$), it was probably a real relationship and not due to chance. So the null hypothesis (H_{20}) of no significant relationship between the use of GenAI tools and creativity skills is rejected. The low magnitude of the correlation, however, implies that the use of the GenAI tools may support creativity development, but it would seem other factors might have a bigger influence on the development of students' creativity.

Table 4: Pearson Correlation between GenAI Tools Usage and Creativity Skills

Variables	1	2
GenAI Tools Usage	1	-
Creativity Skills	.24*	1

Note: Pearson correlation (r) is reported. *$p < .05$ (significant)

H_{03}: There is no significant relationship between generative artificial intelligence tools usage and problem-solving skills among university students in Sindh, Pakistan.

Table 5 shows the Pearson correlation analysis between the use of generative artificial intelligence (GenAI) tools and problem-solving skills among university students of SINDH, Pakistan. The findings indicate that there is a positive weak correlation found between GenAI tools usage and problem-solving skills ($r = .19$, $p < .05$). This finding shows that there is a minor improvement as students use GenAI tools when working on problem-solving. The correlation shows a positive association between GenAI tools usage and Problem-solving skills, though the strength is relatively low, indicating that the usage of GenAI tools has a limited relationship with problem-solving skills. Furthermore, the p value that was determined was statistically significant ($p < .05$), indicating that this observed relationship was not merely due to chance. Thus, the null hypothesis (H_{03}) that was claimed to be "There is no significant relationship between GenAI tools usage and problem-solving skills among university students"

was rejected. Despite the relatively low correlation value, it is possible that other factors related to education, cognition and environment play a more powerful role on problem-solving skills than generative AI tools.

Table 5: Pearson Correlation between GenAI Tools Usage and Problem-Solving Skills

Variables	1	2
GenAI Tools Usage	1	-
Problem-Solving Skills	.19*	1

Note: Pearson correlation (r) is reported. *p < .05 (significant)

Discussion

Discussion The prime objective of the study was to investigate the relationship between the usage of GAT and 21st century skills of the University Students of Sindh, Pakistan in terms of Critical thinking, Creative thinking and Problem-solving skills. The study also looked at the extent to which the use of GenAI tools is related to students' critical thinking, creativity and problem-solving skills in higher education contexts. The results of the first hypothesis showed that the relationship between GenAI tools usage and critical thinking skills was severe and positive. This means students who regularly leveraged GenAI skills had relatively higher critical thinking skills. This result corroborates the works of Grassini (2023) and Baidoo-Anu and Ansah (2023) where they found that AI-supported learning environment is able to improve analytical engagement, reflective thinking and ability of learners to critically assess and analyze information (Alghazo et al., 2025; Ahmad & Rizvi, 2026). The results indicate that with active participation in the analysis and evaluation of AI-generated content, GenAI systems could serve as cognitive assistive tools to enhance students' critical thinking skills. Overall, the results are contrary to those of Firat (2023), who highlighted a potential decrease in independent thinking and passive learning dynamics as the result of relying too heavily on AI tools (Malik, Altaf, & Gull, 2020). This means the benefits GenAI can bring to critical thinking will critically depend on how and for what students will use it (Naz et al., 2025; Ahmad, Noorani, & Channa, 2025).

For the second hypothesis, a positive association was revealed between the use of GenAI tools and creativity skills, albeit not strong, but statistically significant. The results suggest that whilst some GenAI tools might augment creative enhancement, there is limited evidence of their impact. The results concur with Oliveira et al. (2023) that "AI tools can be used to promote divergent thinking and idea generation through exposing students to different perspectives and ideas." Likewise, Rahman and Al-Amin (2024) noted that AI empowerment provides a supportive role in originality and brainstorming in academic environments, including creativity tasks. However, taking an advantage of AI tools for creativity development is not a 1-to-1 relationship, as the weak relationship strength points out possible factors that can be other than AI tools usage. The results suggest a connection with the findings of Baird and Schuller (2023) who insisted on the use of AI-generated ideas that could diminish genuine creativity and the ability to think creatively independently by students (Ahmad, Sewani & Ali, 2024).

For the third hypothesis, the findings indicated a positive correlation between the use of GenAI tools and students' problem-solving skills, but only at a moderately low level and significance. This indicates that the association of the use of GenAI tools with students' problem-solving

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skills is in a limited form. Kim and Lee (2024) have revealed that AI-based learning systems can enhance students' reasoning skills and provide immediate feedback when solving academic issues. Similarly, García and Fernández (2023) reported that students also use AI technologies to examine the different structures of problems and to explore alternative solutions (Ahmad et al., 2024). The low correlation levels observed in this study, however, suggest that mastery of problem-solving abilities might involve more than depending on the technology, and more cognitive involvement, context experience and reasoning (Ali et al., 2023). All these findings also lend assistance to the view of Lee and Kim (2023) that the overreliance on Artificial Intelligence (AI) driven solutions could diminish the cognitive effort of students and opportunities to build solid independent problem-solving skills (Haider, Ahmad, & Ali, 2024). The results of the study suggest that the use of GenAI tools has a high level of correlation with critical thinking, creativity, and problem-solving skills in the opinion of university students, with the level of correlation varying depending on the skill (Ahmad, Bibi, & Imran, 2023). The most clear-cut relationships were found with critical thinking skills, while there were somewhat less definite associations with creativity and problem-solving skills. For cognitive and academic benefits, this implies a positive impact can be achieved primarily when students take an active, critical and balanced relationship with GenAI tools in the education domain.

Conclusion

The present study revealed that usage of the generative artificial intelligence (GenAI) tools is statistically significant with critical thinking, creativity, and problem-solving skills among the University students of Sindh, Pakistan. The results revealed a moderate positive correlation to the use of the GenAI tools and critical thinking skills, suggesting that high-frequency users of GenAI tools showed comparatively higher critical thinking skills. On a different note, creativity and problem-solving skills presented weak but significant positive correlations with GenAI tools usage, indicating that use of AI tools could add to inducing these skills, but the impact seems limited. The research also finds that GenAI tools, with appropriate critical and responsible use, can be complementary educational technologies that support the generation of presentation ideas, information analysis, and educational assistance. But students' independent thinking, originality and in-depth thought processes could be diminished because of an overreliance on AI-generated answers. Thus, the impact of GenAI tools is somewhat contingent on usage in educational settings. In sum, this study emphasises that the use of GenAI tools in higher education is not just about replacing human thinking but also using AI tools as a resource that helps students' thinking and learning. The results published in this study add to the existing body of research on the use of AI use cases in education and offer empirical insights into how the use of AI tools will affect 21st century skills for college students in Pakistan.

Recommendations

- Universities should organize and facilitate training sessions and workshops on responsible, ethical and academic use of GenAI tools, focusing on deepening students' critical thinking, not relying on GenAI technology.
- The faculty should plan learning tasks within the classroom where students have to assess, debate and argue the AI generated outcomes rather than taking them at face value.
- Students are encouraged to leverage GenAI tools for brainstorming, idea generation, and academic guidance, but rely on their own independent thinking when formulating their final answers and arguments.

- University trainings should include more hands-on learning, projects and real-life problems to ensure that creativity and problem-solving are equally integrated with reduced dependence on the use of GenAI. HEIs:
- Have clear rules and regulations of good usage of GenAI tools, to ensure academic integrity and less dependence on copy paste.
- Students need to be educated to use AI tools alongside their own reading, critical thinking, and talking to promote comprehensive learning.

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