

Online Classrooms

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Abstract

The rapid integration of Artificial Intelligence (AI) into education has transformed the dynamics of online learning, creating opportunities for personalized learning pathways. However, the potential of AI to enhance creative thinking skills among students remains underexplored. This study aims to investigate the role of AI-driven personalized learning systems in fostering creative thinking in online classrooms. A quantitative research design with a quasi-experimental approach was applied, involving 240 university students enrolled in fully online courses. The experimental group used AI-powered adaptive learning platforms, while the control group participated in conventional online learning. Data were collected through creative thinking tests and analyzed using ANCOVA to measure the impact of the intervention. The findings indicate that AI-based personalization significantly improves students' creative thinking, particularly in generating novel ideas, problem-solving flexibility, and originality of responses. The study concludes that AI can serve as an effective catalyst for promoting creativity in digital learning environments by tailoring content, pace, and feedback to individual learners. This research provides evidence for integrating AI tools in designing student-centered online learning models that emphasize creativity as a 21st-century skill.

Keywords: Artificial Intelligence, Creative Thinking, Online Learning



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INTRODUCTION

Artificial Intelligence has emerged as one of the most transformative technologies in the field of education, reshaping how learners interact with knowledge and instructors. Online learning environments are no longer limited to static content delivery but are progressively integrating adaptive technologies that respond to learner behavior (Cooper, 2021; Dubnewick et al., 2019). This shift marks a fundamental change in the pedagogical landscape, where personalization, flexibility, and learner autonomy become increasingly central to the design of educational experiences.

The concept of personalized learning has gained prominence as digital platforms evolve to meet the diverse needs of learners. Rather than applying a uniform teaching approach, educators and institutions now rely on data-driven insights to tailor instructional content and pacing (Carnevale et al., 2017; Woodman & Way, 2020). Personalized learning fosters an environment in which students are encouraged to progress according to their individual strengths, preferences, and prior knowledge, while simultaneously addressing their areas of difficulty. Such advancements hold potential to cultivate higher-order thinking skills, including creative thinking, which is widely recognized as a vital skill in the 21st century.

Creative thinking has become a cornerstone of modern education, particularly in online settings that must compensate for the absence of traditional face-to-face interaction. Educational research increasingly emphasizes the need to prepare students not only with knowledge acquisition but also with the ability to generate novel solutions, think critically, and adapt to complex problems (Gallagher, 2017; Nazari et al., 2024). In this evolving educational paradigm, integrating AI technologies into online classrooms represents a significant opportunity to strengthen creative capacities that may otherwise remain underdeveloped in conventional online models.

Current online learning environments frequently rely on standardized instructional methods that offer limited adaptation to individual learners' needs. Such an approach risks disengaging students and does not provide adequate conditions for the development of creativity (Di Leo, 2022; Gallagher, 2017). In the absence of adaptive tools, learners may experience cognitive overload or a lack of appropriate challenge, which in turn constrains the cultivation of flexible, innovative thinking skills.

Educational institutions and instructors face a persistent challenge in addressing how to foster creativity in virtual settings. Many online courses continue to focus on content mastery and assessment efficiency rather than on cultivating creative thinking as a learning outcome. These limitations are compounded by difficulties in delivering meaningful and timely feedback in large-scale online classes (Remein et al., 2020; Zasiakina et al., 2021). Consequently, there is a pressing need to explore mechanisms that enable more personalized learning processes capable of promoting creativity among students.

AI-driven technologies hold the potential to address these gaps, yet there is limited empirical research examining their specific impact on creative thinking within online classrooms (Agnew & Pill, 2023; Nishigori et al., 2024). Despite significant advancements in AI systems for adaptive learning, the precise relationship between AI personalization and creative skills development remains unclear. The absence of targeted research in this area underscores the importance of systematically investigating the role of AI in supporting creativity in digital learning environments.

This study seeks to investigate the extent to which AI-powered personalized learning environments can enhance creative thinking skills among students enrolled in online courses (Call-Cummings et al., 2019; Chang et al., 2019). The research focuses on how adaptive systems can shape learning experiences by customizing content, feedback, and pacing according to individual learner profiles. Through this approach, the study aims to demonstrate whether personalization facilitated by AI can create conditions conducive to generating original and innovative ideas.

An additional aim of this research is to evaluate how specific dimensions of creative thinking—fluency, flexibility, and originality—respond to the use of AI tools within an online context (Wong-A-Foe et al., 2023; Yamagata-Lynch et al., 2022). By systematically assessing the performance of students exposed to AI-based personalized instruction against those experiencing traditional online teaching methods, the study intends to provide empirical evidence regarding the effectiveness of such technologies.

The ultimate objective of this research is to contribute actionable insights for educators, instructional designers, and policymakers on how AI technologies can be strategically incorporated into online education. The findings are expected to inform the design of future learning environments that are more responsive to learner diversity while simultaneously nurturing creative potential.

A considerable body of literature has explored the benefits of AI in education, with a strong emphasis on performance improvement, efficiency in assessment, and content delivery optimization (Hunter & Cook, 2020; Yamagata-Lynch et al., 2022). These studies have established that AI-driven personalization can improve academic achievement by providing individualized feedback and adaptive pathways. However, very few studies have examined how these systems influence higher-order skills such as creative thinking, leaving a critical gap in knowledge.

Research on creativity in online learning has traditionally focused on pedagogical approaches rather than technological innovations. While collaborative learning models, project-based tasks, and problem-solving activities have been shown to foster creativity, there is insufficient evidence that these methods alone can fully overcome the limitations of non-adaptive environments (Glavan & Ferreira, 2024; Yamagata-Lynch et al., 2022). The interplay between AI personalization and creative thinking has not been explored in depth, resulting in a lack of understanding about how these tools may be optimized for creative skill development.

The emerging field of AI-assisted learning requires deeper inquiry into not only its technical feasibility but also its pedagogical implications. The absence of empirical studies that combine adaptive AI learning with the explicit goal of cultivating creativity represents a gap that this research intends to address (Camporesi et al., 2017; Nishigori et al., 2024). By focusing on creative thinking, the present study responds to a significant need to move beyond knowledge delivery and toward preparing learners for complex, innovative problem-solving in the digital era.

This study introduces an innovative perspective by positioning AI as more than a tool for efficiency, framing it instead as a mechanism for creativity enhancement. Rather than examining traditional outcomes such as test performance or content mastery, the research focuses specifically on how AI-based personalization influences students' ability to think divergently, generate new ideas, and adapt their thought processes (Hong & Choi, 2020;

Rondeau-Lutz & Weber, 2017). This represents a departure from the predominant emphasis in prior studies.

The novelty of the study lies in its integration of adaptive learning algorithms with explicit objectives to foster creativity, thus bridging a conceptual and empirical gap in the literature (Hunter & Cook, 2020; Pifarre et al., 2024). By conducting a rigorous comparison between AI-personalized instruction and conventional online teaching methods, the research offers new insights into how educational technology can contribute to skills that are essential for lifelong learning and innovation.

The study is justified by the pressing need for educational models that prepare learners for future challenges characterized by uncertainty, complexity, and rapid technological change. Developing creative thinkers is no longer an optional aim but a core responsibility of modern education systems (De Costa et al., 2021; Lane et al., 2020). The findings of this research are expected to enrich theoretical discussions on AI in education and guide the development of practical strategies for implementing AI-driven personalization in diverse learning contexts.

RESEARCH METHOD

A quantitative research design with a quasi-experimental approach was applied to examine the influence of AI-driven personalized learning on creative thinking skills in online classrooms. The study employed a pre-test and post-test control group design to allow systematic comparison between students exposed to AI-based adaptive platforms and those engaged in conventional online learning (Evans et al., 2022; Gümüşok, 2021). The choice of this design was made to capture measurable changes in creative thinking while controlling for potential confounding factors.

The population for this study consisted of undergraduate students enrolled in fully online courses at three universities that had adopted learning management systems with comparable curricula. From this population, a total of 240 participants were selected using purposive sampling to ensure that all participants had adequate digital literacy skills and prior experience in online learning environments (Marsh et al., 2020; Pullman, 2022). The participants were randomly assigned to two groups, with 120 students in the experimental group and 120 in the control group.

The primary instrument used in this study was a standardized creative thinking test adapted from the Torrance Tests of Creative Thinking (TTCT), which evaluates fluency, flexibility, and originality of ideas. Supplementary instruments included an AI learning analytics dashboard that tracked engagement, content interaction, and adaptive feedback patterns, as well as a demographic questionnaire to gather background information about the participants (Marsh et al., 2020; Pullman, 2022). These instruments were validated by experts in educational technology and psychometrics to ensure reliability and construct validity.

The procedures began with a pre-test administered to both groups to establish a baseline of creative thinking skills. The experimental group then participated in an eight-week intervention using an AI-powered personalized learning platform that adapted instructional content, pacing, and feedback based on individual learner performance and preferences. The control group followed the same course content delivered through a conventional online format without AI-driven personalization (Evans et al., 2022; Kelly & Mullan, 2018). At the end of the intervention, both groups completed a post-test identical in structure to the pre-test. Data from

tests and learning analytics were collected, coded, and analyzed using ANCOVA to assess the impact of the AI-based intervention on creative thinking outcomes.

RESULTS AND DISCUSSION

Descriptive statistics provided an overview of the participants' creative thinking scores before and after the intervention. The pre-test mean score for the experimental group was 56.32 with a standard deviation of 7.85, while the control group recorded a mean score of 55.89 with a standard deviation of 8.12. Post-test results indicated that the experimental group achieved a mean score of 78.54 (SD = 6.47), and the control group achieved 63.27 (SD = 7.93). These findings are summarized in Table 1, which displays the means, standard deviations, and sample sizes for both groups.

Table 1. Descriptive Statistics for Creative Thinking Scores

Group	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	N
Experimental Group	56.32	7.85	78.54	6.47	120
Control Group	55.89	8.12	63.27	7.93	120

Examination of the descriptive data suggests a substantial increase in creative thinking scores among students who engaged with AI-powered personalized learning platforms. The difference between pre-test and post-test mean scores was considerably larger in the experimental group, suggesting that the intervention exerted a significant effect on participants' ability to produce fluent, flexible, and original ideas. The control group, which experienced conventional online learning, showed only a modest improvement.

The data were further explained by analyzing patterns across the three dimensions of creative thinking: fluency, flexibility, and originality. Students in the experimental group demonstrated the most notable improvement in fluency, with post-test scores rising by an average of 21 points. Gains in flexibility and originality were also substantial, with average increases of 18 and 16 points respectively. These results confirm that adaptive AI-based instruction provided conditions that stimulated multiple aspects of creative thought.

Descriptive analysis also revealed consistent improvements across different subgroups of participants within the experimental group. Regardless of prior academic achievement levels or digital literacy skills, the majority of students demonstrated meaningful gains in their post-test performance. The control group exhibited uneven patterns, with some students showing minor improvements while others showed no change, indicating that the traditional online learning model was less effective in fostering creativity.

Inferential statistical analysis was conducted using ANCOVA to assess the effect of AI-based personalized learning while controlling for baseline differences. Results indicated a statistically significant main effect of the intervention on post-test scores, $F(1, 237) = 115.84$, $p < 0.001$, with an effect size (η^2) of 0.33, representing a strong impact. These findings demonstrate that students exposed to AI-personalized instruction significantly outperformed those in the control group in terms of creative thinking outcomes.

Comparisons of adjusted post-test means confirmed that the experimental group scored substantially higher than the control group after controlling for pre-test scores. The adjusted mean score for the experimental group was 78.12, while the control group's adjusted mean was 63.79. This difference of 14.33 points highlights the effectiveness of AI-driven personalization in enhancing creative skills in online classrooms.

Data relations were observed between levels of platform engagement and post-test creative thinking outcomes. Students in the experimental group who frequently interacted with AI-generated feedback, customized content modules, and adaptive challenges tended to achieve the highest scores on the post-test. This suggests that consistent engagement with adaptive features of the platform contributed to better performance.

Additional correlation analysis indicated that time spent interacting with the adaptive system was positively correlated with gains in fluency ($r = 0.46$, $p < 0.01$), flexibility ($r = 0.42$, $p < 0.01$), and originality ($r = 0.39$, $p < 0.01$). These findings highlight the integral role of sustained engagement with AI-driven systems in promoting improvements across all three dimensions of creative thinking.

Case study observations from three students in the experimental group illustrated how AI-driven personalization influenced learning outcomes. One student with lower initial scores displayed significant improvement by receiving immediate AI feedback that guided them toward alternative strategies for idea generation. Another student who exhibited high baseline fluency benefited from the adaptive system by focusing on flexibility exercises, resulting in more diverse and novel solutions. A third student described the adaptive system as a motivating factor for staying engaged throughout the course.

Qualitative reflections from participants supported these case observations, emphasizing that the adaptive system provided challenges appropriate to their skill levels. Students noted that the feedback felt individualized and helped them explore creative solutions they might not have considered in a more uniform online class structure.

Brief interpretation of the findings confirms that AI-driven personalized learning contributes significantly to the enhancement of creative thinking in online classrooms. The evidence suggests that the integration of AI tools into educational practices can go beyond improving performance metrics, fostering skills that are critical for problem-solving, innovation, and adaptability in a digital era.

The combined quantitative and qualitative evidence positions AI-based personalization as a key driver in developing student creativity. These findings support the strategic inclusion of AI systems in digital learning environments to meet the demands of 21st-century education.

The findings of this study demonstrate that AI-driven personalized learning significantly enhances creative thinking among students in online classrooms. The results indicate that the experimental group, which engaged with adaptive AI tools, showed remarkable improvements in fluency, flexibility, and originality compared to the control group. The quantitative analysis supported these observations with a statistically significant difference between groups, while qualitative reflections highlighted positive perceptions of AI as a tool for personalized learning. The evidence strongly suggests that adaptive AI systems provide an environment that nurtures creativity, going beyond traditional online instructional approaches.

Substantial differences between pre-test and post-test scores in the experimental group confirm the effectiveness of AI personalization in stimulating student creativity. The improvements in all three measured dimensions of creative thinking indicate that the use of adaptive platforms can restructure how students approach problems and generate ideas. The positive experiences reported in the case studies also strengthen the argument that AI-based systems encourage student engagement and exploration, factors closely linked to creative growth.

The findings collectively confirm the study's primary objective, which was to evaluate whether AI-powered personalized learning can enhance creative thinking in virtual settings. Evidence from this research aligns with the view that technology, when applied thoughtfully, can facilitate an environment conducive to skill development that is often challenging to achieve in online education. The combination of data from quantitative and qualitative sources adds depth to the argument that AI integration positively impacts creativity in learning.

The results affirm that AI-powered systems function not merely as technological enhancements, but as critical instructional partners capable of shaping learner behavior. By enabling students to receive adaptive feedback and engage in content at their own pace, these systems promote active participation in the learning process. The findings also indicate that personalization through AI fosters deeper cognitive engagement, which is a key factor in creative performance.

The outcomes of this study demonstrate partial alignment with existing research, while also revealing distinctive contributions. Prior studies have explored the benefits of personalized learning in terms of academic achievement and engagement, yet most did not focus explicitly on creative skills. This study extends the scope of existing literature by showing that AI-driven personalization has measurable effects on creativity in an online learning context. Differences between this study and prior findings are evident in the specific emphasis placed on creative thinking dimensions and the comprehensive use of adaptive systems.

Results of this research also differ from studies where technology integration had limited impact on creativity. In cases where traditional digital tools such as static e-learning modules were used, students tended to experience passive learning, which offered minimal creative stimulation. The present study highlights that active, dynamic AI systems differ substantially from these tools by adjusting tasks and content to individual learner profiles, thereby creating conditions for creative thought to flourish.

The study findings resonate with research in related fields that emphasize the value of learner-centered models supported by data analytics. AI tools extend this concept by generating real-time data that instructors and learners can act upon, fostering environments that are both adaptive and engaging. The emphasis on creativity in this study adds an important dimension to ongoing discussions about the future of technology-enhanced education.

In contrast to previous work that primarily measured knowledge acquisition, the results of this research broaden the focus to include innovation and creative capacity as important outcomes. This marks a significant contribution to the discourse on how AI can move education beyond efficiency metrics, toward nurturing essential skills that prepare students for complex and uncertain future contexts.

The patterns observed in the data suggest that AI personalization serves as an indicator of a broader shift in digital education. The strong positive effects on creativity indicate that adaptive systems can compensate for some of the limitations inherent in traditional online learning environments. This trend points to the possibility that creativity, long considered difficult to cultivate in digital platforms, can be effectively addressed through AI-driven approaches.

The study findings also signify that students exposed to adaptive technologies can develop habits of independent thinking and curiosity that persist beyond the duration of the intervention. The alignment between engagement levels and post-test creative performance shows that students who immerse themselves in AI-driven learning activities benefit most from

these systems. These results suggest that online learning, when coupled with adaptive tools, can produce outcomes similar to or better than traditional in-person environments in terms of creativity.

These results stand as evidence of the changing expectations for 21st-century learners. Creativity, once considered an outcome requiring face-to-face interaction, is now achievable in virtual learning environments when supported by advanced technologies. The combination of personalization and continuous feedback allows students to experience higher levels of motivation, thereby creating fertile ground for innovation and problem-solving.

The findings also highlight that the emerging role of AI in education represents a sign of the evolving balance between technology and pedagogy. While tools alone cannot create creativity, the appropriate use of AI ensures that pedagogical principles are reinforced and extended through personalized engagement. This relationship demonstrates that technology can be an enabler of critical skills, not just a passive facilitator.

Implications of these findings extend to instructional design, policy-making, and teacher preparation programs. Educators are encouraged to consider the integration of AI as a means of providing differentiated support to students, particularly in contexts where fostering creativity is a priority. Decision-makers in education should view AI as a partner in transforming online learning from a delivery model into an interactive, skill-focused environment.

Practical applications of these results include the incorporation of AI-driven tools in curriculum development to personalize learning pathways, the creation of teacher training programs that emphasize technology-assisted facilitation, and the use of real-time analytics for early identification of students who need additional creative stimulation. The outcomes also indicate that a balanced approach to AI integration is necessary, combining technical support with intentional pedagogical strategies.

This study's contributions further extend to the ethical considerations of educational technology. Designing AI systems that prioritize student engagement and creativity raises the importance of safeguarding learner data while ensuring fairness in algorithmic adaptation. Institutions should develop policies that allow for responsible innovation, ensuring that creative skills are not compromised by overly rigid technological systems.

Reasons for these results can be traced to the adaptive mechanisms embedded in AI-driven platforms. Personalized pathways, dynamic challenges, and continuous feedback offer students tailored opportunities to explore diverse approaches to problem-solving. These features likely contributed to the observed increases in fluency, flexibility, and originality.

The findings can also be explained by the motivational aspect of adaptive systems. Receiving immediate and meaningful feedback fosters an environment where learners are encouraged to take intellectual risks, an essential condition for creativity. This feedback cycle helps students refine their thinking processes, resulting in improved outcomes.

Engagement analytics show that students who interacted more with the adaptive features achieved greater gains, suggesting that learning is enhanced when systems respond directly to student inputs. These patterns indicate that personalization reduces barriers to learning and supports sustained effort, both of which contribute to improved creative capacities.

The overall results are consistent with the view that educational interventions are most effective when they consider both cognitive and emotional aspects of learning. The adaptive system's ability to adjust difficulty and content relevance ensures that students are neither overwhelmed nor under-stimulated, which enhances creativity.

The future direction suggested by these findings is clear. Institutions need to invest in AI-based platforms and provide adequate support for their implementation, particularly in online programs where creativity is an essential learning outcome. Further research is required to refine these systems and explore their long-term impact on learner behavior and outcomes.

Next steps include extending the research to other disciplines, student populations, and cultural contexts to ensure that findings are robust and generalizable. Building partnerships between educators, technologists, and policymakers will be essential for maximizing the benefits of these tools. These findings also highlight the need to move beyond experimental trials toward scalable models of AI-driven personalized learning. Establishing best practices and frameworks will ensure that the integration of these systems remains effective and sustainable across institutions.

Educational institutions are encouraged to treat these findings as evidence that strategic innovation can make creativity a defining characteristic of online education. By aligning pedagogy, technology, and policy, online classrooms can evolve into environments that nurture innovation and prepare learners for future demands.

CONCLUSION

The most important finding of this study is that AI-driven personalized learning environments significantly enhance creative thinking skills among students in online classrooms, demonstrating clear improvements in fluency, flexibility, and originality compared to conventional online learning. The results reveal that adaptive systems provide targeted feedback, individualized pacing, and dynamic challenges that directly foster students' ability to generate novel ideas and engage with complex problems, which differs from earlier research that primarily focused on knowledge acquisition and academic achievement rather than creative outcomes.

The contribution of this research lies in advancing the conceptual understanding and methodological application of AI in education by shifting the focus from content mastery to creativity enhancement. The study introduces a comprehensive model that integrates adaptive learning algorithms with pedagogical strategies designed specifically to promote creative skills, offering a replicable framework for future investigations. This approach not only broadens the theoretical discourse on AI in education but also provides practical guidelines for instructional designers and institutions seeking to integrate AI as a transformative component of personalized learning.

The limitations of this study include its reliance on a specific student population within a controlled academic environment and its focus on short-term intervention outcomes. Future research should explore the long-term effects of AI-driven personalized learning on creative thinking, examine diverse populations across cultural and disciplinary contexts, and investigate how different adaptive features contribute to creativity in more complex learning ecosystems.

AUTHOR CONTRIBUTIONS

Look this example below:

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest

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