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How does student creativity depend on teaching methods at the institute? Modern information technologies for education and creativity as manifestations of the specifics of the psyche

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ABSTRACT

This study analyzes the impact of project-based learning (PBL) and SCAMPER techniques on fostering creativity among university students. PBL, a dynamic classroom approach, engages students in acquiring knowledge and skills through an extended inquiry process centered around complex, authentic questions and carefully created products and activities. The creative thinking method known as SCAMPER – which stands for Substitute, Combine, Adapt, Modify, Put to another use, Eliminate and Reverse – helps students explore novel solutions. We investigate how these student-centered teaching methods, along with personal characteristics like self-efficacy and adaptability in problem-solving, promote creativity in higher education environments. A total of 150 junior students participated in the study, collaborating on various structured group assignments through the Moodle platform. The study assessed students' creative abilities and motivational orientations using the Torrance Test of Creative Thinking (TTCT), personality tests and the Work Preference Inventory (WPI). The research design employed a quasi-experimental approach to quantitatively and qualitatively investigate how instructional tactics influenced students' creativity and problem-solving skills. The findings showed that PBL and SCAMPER greatly enhanced students' flexibility, inventiveness and fluency. Improved creative performance was found to be positively correlated with characteristics like achievement orientation and self-efficacy. Additionally, the collaborative interactions made possible by digital platforms strengthened students' creative outputs. These results imply that combining cutting-edge pedagogical approaches with digital tools might significantly improve student learning outcomes in fields like engineering and medical education, which place a high value on creativity and innovation.

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Introduction

One of the most important abilities of the twenty-first century is creativity in a society that is becoming more linked and fast-paced. Higher education institutions, such as universities and specialized training centers, are supposed to foster students' creative thinking in order to provide them with the skills necessary for innovative problem-solving, adaptation and complexity in a variety of professional settings. However, encouraging creativity is not easy, and one of the main obstacles is how instructional strategies affect students' capacity for creativity. The best pedagogical strategies for balancing creative engagement and information transmission are a challenge educators face everywhere (Kevin et al., 2024).

In design education, creativity is important for coming up with answers or developing fresh concepts. Assessing creativity can help find novel ideas. 'Futures education' is a visionary approach to education

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that transcends traditional, linear and short-term thinking. Instead, it pushes students to prepare for a range of conceivable, desired and doable futures. Future education aims to help students improve their critical thinking, creativity, adaptability, resilience and decision-making abilities (Chaudhuri & Dhar, 2024; Isidori et al., 2023).

This is in contrast to the more traditional educational system, which frequently concentrates on imparting a set body of knowledge. To assist students and influence their future rather than respond to it, it aims to provide a forum for them to examine current trends, evaluate their implications and envision future situations (Sayaf et al., 2021).

Studies have shown that the rigid structures of traditional education, which emphasize memorizing by rote and testing by standards, do not adequately prepare students for the rigorous demands of the modern workforce. Therefore, strong university–industry partnerships may be fostered by the technology-supported cross-organizational Communities of Practice integrated into the Higher Education curriculum for Design Studies (Mavri et al., 2024). In the rapidly changing field of education, there is an increasing demand for creative methods of instruction and evaluation. It has long been maintained that conventional approaches to teaching mathematics encourage rote learning and memorization at the price of developing the critical and creative thinking abilities required to address problems in the real world (Li, 2022; Nilimaa, 2023).

The passive learning paradigm, in which students are only information consumers, is among the most often mentioned problems. Research indicates that this method, still prevalent in many regions of the world, limits students' ability to think creatively and discourages experimentation and independent thought. Active learning techniques, on the other hand, such as problem-solving exercises, project-based learning (PBL) and open dialogues, are thought to promote creativity better. For instance, studies indicate that student-centered learning, which promotes inquiry and teamwork, may significantly enhance creative outputs. However, the worldwide movement toward more innovative pedagogies is occasionally hampered by large class sizes, a lack of funding and deeply ingrained cultural perspectives on education (Xhomara, 2022).

The global need for innovative thinking in education is driven by the need for skills that can adjust to complex, unanticipated difficulties in contemporary economies. According to research, students in countries with top-notch educational systems often have more sophisticated creative thinking abilities (Patston et al., 2021). But even in these institutions, antiquated educational strategies prioritizing standardized testing and constrictive conceptions of academic success can prevent creativity from fully developing. However, not all teaching methods work well for establishing such an environment. Strict and authoritarian teaching approaches that instill a fear of failure may prevent students from taking intellectual risks, which are necessary for the development of creative problem-solving abilities (Feist, 2019).

Modern information technologies are revolutionizing creativity and education by providing new opportunities and tools to foster creative learning beyond instructional practices. The delivery of information and the way that students interact with it are changing as a result of digital platforms, artificial intelligence and interactive media. For example, the increasing adoption of interactive technologies like Minecraft Education Edition or collaborative platforms like Google Classroom has enabled educators to implement gamified learning experiences, increasing student engagement and creativity (Mohd et al., 2023).

In a world of education where encouraging creativity and invention is becoming increasingly important, the SCAMPER approach stands out as a crucial strategy for developing these abilities in college settings. With its structured yet adaptable framework, SCAMPER – an acronym for Substitute, Combine, Adapt, Modify, put to another use, Eliminate and Reverse – invites students to consider preexisting concepts and items in fresh ways. This method aligns with the educational requirement to equip students to solve challenging problems and be creative in their domains (İslim & Karataş, 2016).

Contemporary information technologies have created new avenues for tackling these issues. Innovative approaches to engage students and promote creativity can be found in the use of digital tools, including artificial intelligence-driven educational software, online platforms, virtual laboratories and interactive instructional materials (Haleem et al., 2022). The digital gap is still a major global problem, though. Lack of access to contemporary technologies limits creative learning opportunities in underdeveloped countries. In contrast, over-reliance on technology or inadequate training can make it

difficult for educators in more developed countries to successfully incorporate these tools into the curriculum (Afzal et al., 2023).

Even with these developments, more is needed about the potential of information technology to foster creativity. Numerous studies agree that technology may improve participation and open up new avenues for creative expression. Yet, there are worries that instead of promoting autonomous creative ideas, technology may increase reliance on outside resources. For instance, Stanford University research found that although digital technologies have the potential to democratize information access, if they are not employed carefully within an innovative educational framework, they run the danger of producing shallow learning experiences (Bereczki & Kárpáti, 2021).

This study fills in the knowledge vacuum about how particular institutional teaching strategies, when paired with contemporary information technology (IT) tools, can either support or undermine student creativity. Through an examination of worldwide patterns and the distinct psychological makeup of students, this research aims to elucidate the most efficacious methods for fostering creativity in learning settings. Furthermore, this article adopts a more integrated perspective, looking at the interaction between pedagogical approaches and digital tools, in contrast to earlier studies that frequently separated teaching methods or technology in their analyses. This all-encompassing strategy offers new perspectives on how creativity changes in the educational process.

This research offers a reflective look at how different teaching approaches interact with students' cognitive and emotional capacities by presenting authentic data gathered from institutions that have used creative learning methodologies. The results correct some of the imbalances from previous studies, including an over-emphasis on technology or instructional strategies, and add to the current discussions about how education will develop in the digital era. Through an emphasis on the psychological aspects of creativity and the particular learning contexts that foster it, this essay offers fresh insights into a subject that is becoming more and more important on a worldwide scale.

Literature review

Recent research highlights a global shift toward student-centered teaching, moving from traditional rote memorization to active learning strategies, such as PBL and problem-solving. These methods encourage creative engagement. Digital tools have also revolutionized education, particularly in developed nations like the United States, where educational apps have been incorporated into schools since 2010. Digital games have also impacted the creative development of college students. These tools support a variety of learning styles and offer chances for collaboration, creativity and engagement across curricula, improving motivation and communication while satisfying a wide range of student needs (Alqahtani, 2024; Yang et al., 2024).

However, the adoption of contemporary IT in teaching has given rise to both hope and worry. Digital tools and platforms present novel opportunities for creative interaction, offering students dynamic learning experiences that are beyond the limitations of traditional classroom settings. Research on technology-enhanced learning settings has shown a correlation between better levels of student creativity and the usage of gamified learning platforms and collaborative digital tools. For instance, real-time collaboration and the application of creative problem-solving abilities in a dynamic environment are made possible by platforms such as Google Classroom and Minecraft Education Edition (Eden et al., 2024; Ng et al., 2023).

Literature frequently discusses the impasse over how best to strike a balance between the use of technology and creative teaching. Some studies suggest a strong IT integration to boost student creativity, but others point out that technology cannot stimulate creativity on its own if there is no associated educational framework in place (Chappell & Hetherington, 2024). Research comparing conventional and digital learning environments reveals that the quality of the teaching approaches is frequently more closely associated with creative outcomes than the usage of digital technologies per se. As a result, creativity has been integrated into the aims of education systems in many nations (such as South Korea, China, Singapore, etc.) through educational policies, and it is now a crucial learning objective for all K–12 students (Liu et al., 2023).

Research has demonstrated that SCAMPER can effectively stimulate divergent thinking by encouraging students to explore multiple options from a given scenario, increasing their cognitive flexibility and creative output (Abdallah et al., 2023; Ozyaprak, 2016). For instance, a study by Tuba Altiparmak examines the effects of SCAMPER technique-based educational activities in the simple machines unit of a science lesson on students' academic achievement, motivation and attitude. Despite its widespread use, the potential of the SCAMPER approach for fostering creativity has not been fully explored in higher education (Altiparmak & Eryilmaz-Muştu, 2021).

The implementation of SCAMPER is not without its difficulties, though, as some educational researchers argue that students may find it challenging to apply the abstract principles of SCAMPER in real-world situations without the right guidance and context (Idek, 2016). There is a lack of empirical research examining the longitudinal impact of SCAMPER on students' creative self-efficacy – a gap that current educational research is starting to fill. Critics also argue that the effectiveness of SCAMPER is highly dependent on the instructional context and the student's initial level of creative capacity (Ozyaprak, 2016).

According to some studies, creativity is a socio-psychological phenomena that is influenced by interactions between environmental and cultural elements. The household and the school are the two primary environments that shape the creative development of children and adolescents. Vietnam's new general education curriculum, which emphasizes creativity in addition to making IT a required topic for grades 3–9, reflects the government's increasing focus on digital education. Even though IT is still an elective in high school, these modifications represent a nationwide movement toward digital learning and emphasize the significance of IT in today's curriculum (Katayev & Burdina, 2023; Nguyen et al., 2023).

There are also evident methodological problems in this field. A quantitative approach is used, measuring creativity using standardized exams; nevertheless, some contend that this technique falls short of capturing the richness and nuance of creative thought. A more complex picture of how creativity is fostered is frequently presented by qualitative research, which focuses on the emotional components of learning and the personal experiences of the students. These researchers are constrained, nevertheless, by lower sample numbers and the challenge of extrapolating findings to larger groups (Adu et al., 2022; Shcherbakova et al., 2024; Ugwu & Val, 2023). The lack of attention paid to the psychological aspects impacting creativity in educational settings is another notable gap. While the role of teaching methods or technology has been examined, few consider the cognitive and emotional aspects of how students process creative tasks. The absence of these psychological factors creates a knowledge vacuum on how teaching methods interact with the mental and emotional processes that underpin creativity (Henriksen et al., 2021).

In conclusion, there are still a lot of unanswered questions about the relationship between instructional strategies, IT resources and creativity. More thorough and integrative research is required to completely understand how these elements interact in encouraging student creativity, as shown by methodological disputes, a restricted focus on psychological issues and a lack of long-term studies. Future research can fill up these gaps and offer educators and legislators more precise recommendations on how to encourage creativity in the classroom.

Problem statement

This study is driven by the growing recognition of the value of encouraging creativity in the classroom, particularly in the context of the digital revolution. Many educational institutions lack a defined framework for combining instructional methodologies and digital resources to encourage creative thinking despite the broad acceptance of creativity as a crucial ability. The goal of this research is to determine the best mix of contemporary technology and instructional approaches to foster creativity. Finding worldwide patterns, evaluating psychological and sociocultural aspects, and creating a workable model to maximize creativity in educational settings are among the goals. The ***goal of this research*** is to provide fresh perspectives on efficient teaching strategies that may be applied in traditional and digital settings.

The study was driven by several ***research tasks***:

1. To assess how SCAMPER and PBL affect students' capacity for originality, fluency, elaboration, and flexibility in their creative thought processes.
2. To examine the ways in which personality qualities like flexibility in problem-solving and self-efficacy affect creativity in a group learning setting.
3. To look at the relationship between advances in creativity following the application of creative teaching techniques and both intrinsic and extrinsic motivation.
4. To evaluate how well digital tools – Moodle in particular – achieve the goal of raising students' creativity and engagement levels in group assignments.

Methodology

This study investigates how instructional tactics and contemporary information technologies impact student creativity. It does this by utilizing PBL and SCAMPER teaching methodologies. These approaches are renowned for encouraging students to think creatively and solve problems by including them in practical group projects. The SCAMPER is a creative technique that encourages innovation by prompting users to Substitute, Combine, Adapt, Modify, Put to another use, Eliminate, or Reverse elements of a product, process or idea. The SCAMPER method fosters diverse thinking in students by pushing them to reconsider and adjust project components.

Research design

The study was carried out at I.M. Sechenov First Moscow State Medical University (Russia) and L.N. Gumilyov Eurasian National University (Kazakhstan) over the course of one academic year. The study used a quasi-experimental design to investigate how students' motivation, creativity, and collaborative engagement are affected by creative teaching approaches (such as PBL and SCAMPER).

The research was structured into four stages (Table 1).

Stage 1: Pre-evaluation and Group Establishment

- Objective: Assess the personality qualities and baseline levels of creativity of the students.

- Method: To evaluate students' creativity in areas including fluency, originality, elaboration, and flexibility, the Torrance Test of Creative Thinking (TTCT) was given to them during the first few weeks of the research. Questionnaires measuring motivation, flexibility in problem-solving and self-efficacy were used to quantify personality characteristics.

- Outcome: Students were divided into groups according to their TTCT scores, guaranteeing that each group included various subjects and degrees of creativity.

Stage 2: An Overview of Innovative Teaching Techniques

- Objective: Introduce students to the teaching strategies and resources.

- Method: Through lectures and hands-on exercises, students were exposed to PBL and the SCAMPER technique. There were instructions on how to use the Moodle platform for teamwork, communication and group projects.

- Outcome: Through SCAMPER exercises, students started honing their creative thinking skills and were acquainted with Moodle's features.

Table 1. Research design overview table.

Stage	Objective	Method
1	Assess personality qualities and baseline creativity	Administer the Torrance Test of Creative Thinking (TTCT) and personality questionnaires
2	Introduce teaching strategies and resources	Provide lectures and hands-on exercises on PBL and SCAMPER; introduce Moodle platform for collaboration
3	Implement teaching techniques in practical assignments	Use SCAMPER and PBL methods for group projects; utilize Moodle for collaboration and communication
4	Evaluate the impact of teaching strategies	Retake the TTCT and reevaluate personality and motivation traits; gather qualitative data via Moodle

Stage 3: Execution of the Project:

- Objective: Integrate innovative teaching techniques into practical assignments.

- Method: Using the SCAMPER approach and PBL methodologies, students completed organized projects in groups over the course of the next few months. Moodle was used by them for teamwork, file sharing and communication. Regular peer and teacher feedback sessions and group discussions took place.

- Outcome: Students actively participated in group-based problem-solving while investigating various strategies for handling project obstacles.

Stage 4: Post-Evaluation and Introspection

- Objective: Assess how innovative teaching strategies affect students' capacity for creativity and teamwork.

- Method: To gauge any increases in creativity, students retook the TTCT after the school year. They underwent a reevaluation of their motivation and personality attributes, and via project presentations and Moodle conversations, qualitative data on group dynamics was gathered.

- Outcome: Data were examined to ascertain how the instructional strategies affected students' involvement, creativity and teamwork.

Participants

A total of 150 junior students, ages 18–25, from L.N. Gumilyov Eurasian National University (Kazakhstan) and I.M. Sechenov First Moscow State Medical University (Russia) participated in this study. The sample size took into account the range of academic backgrounds and creative levels while ensuring statistical power. Based on their results from the TTCT, students were split into 15 groups to evaluate creativity in a variety of educational and cultural situations (Table 2).

Students in their third and fourth years were chosen because they span a range of ages and academic backgrounds that reflect people who have acquired the foundational knowledge and critical thinking skills required for SCAMPER and PBL. Since they are moving into specialized industries, these students are especially well-suited for creative problem-solving and teamwork, which offers a strong foundation for implementing sophisticated instructional approaches.

This sample strategy made a thorough examination of the effects of innovative teaching strategies on students from a range of academic fields and cultural backgrounds possible.

Each group participated in SCAMPER and PBL through the Moodle platform, enabling online interaction, collaboration and supervised learning. The students were given clear instructions and cutting-edge tactics to encourage creativity, critical thinking and problem-solving abilities.

Throughout the project, instructors from both universities received continuous assistance thanks to attending seminars on creative educational strategies. Due to the practical nature of the exercises, students were able to focus on combining disciplinary and cultural views while exploring creative solutions in groups.

Initially, the study did not explicitly compare creativity between the two universities or between academic levels. The selection of students from these particular levels and institutions was necessary, nonetheless, to comprehend the possible variations in creativity growth brought about by institutional effects and educational progression. These dimensions could be thoroughly examined in future investigations.

Experimental procedures

The experiments were carried out in classes essential to disciplines like computer science, engineering and medicine that strongly emphasize creativity. These classes were chosen because they support the

Table 2. Demographic characteristics of the participants.

Total participants	150 junior students
Age range	18–25 years
Gender Distribution	45% female, 55% male
Academic Levels	Third and fourth-year students.
Universities	L.N. Gumilyov Eurasian National University (Kazakhstan) and I.M. Sechenov First Moscow State Medical University (Russia).

Table 3. Course timeline and activities.

Week(s)	Activity
1	Course Introduction and Initial Assessments
7-Mar	Project Planning and Preparation
14-Aug	Project Implementation
15–16	Project Presentation and Peer Review
17	Submission and post-assessments

objectives of encouraging creativity through student-centered and active learning approaches. For SCAMPER and PBL, each group used the Moodle platform, which allowed for interactive, group and supervised learning. Due to the activities' practical nature, students were able to explore innovative solutions in groups while integrating disciplinary and cultural views.

The task was created with student-centered instructional objectives and contemporary teaching methods in mind. The courses were spread out over two 16-week academic semesters (Table 3). There were two 90-min classes held each week.

The course goals were presented by the teachers during the first week, with a focus on PBL and the SCAMPER approach. After completing the TTCT to gauge their initial levels of creativity, students were divided into many groups according to the findings. In order to become acquainted with Moodle's collaborative features, students also received instructions on how to use it.

Students discussed ideas, made goals and planned their assignments utilizing SCAMPER's creative thinking dimensions (substitute, combine, adapt, modify, put to other uses, remove and rearrange) throughout Weeks 3–7 as they prepared for their projects. These factors served as a roadmap for creating fresh solutions for the difficulties they were given.

The project was implemented between weeks 8 and 14. Using Moodle, groups worked together to produce projects. They split chores, exchanged ideas, and received ongoing feedback from instructors and peers. This stage strongly emphasized applying newly taught concepts, solving problems and critical thinking.

Students used the file-sharing and video features of the site to display their ideas during Weeks 15–16. Peers and teachers both gave evaluations of the presentations, including comments on their technical and artistic qualities. Students could then revise and reflect on their work, making necessary improvements in response to criticism.

Ultimately, during Week 17, students turned in their updated reports and finished post-assessments, which included the TTCT, the Motivation Work Preference Inventory (WPI), and personality and problem-solving style questionnaires.

Data collection

Before and after the experiment, the TTCT evaluated creative skills such as fluency, flexibility, originality and elaboration. A personality questionnaire assessed students' accomplishment objectives and approaches to problem-solving, while the WPI assessed their intrinsic and extrinsic motivation. Moodle was also used to gather data from presentations and group conversations to gain a qualitative understanding of creative involvement and cooperation.

Data analysis

Quantitative data were examined using SPSS, which applied regression analysis, correlation and descriptive statistics to evaluate the connections between instructional strategies and creativity. The study employed a thematic analysis approach to examine student perspectives on creative development and their experiences with digital technologies for collaborative learning. The data was gathered through interviews, discussions and project feedback.

The statistical analysis was conducted using the subsequent methodologies:

1. Descriptive Statistics: To provide an overview of important data characteristics such as mean and standard deviation.

2. Correlation Analysis: To investigate the connections between creativity traits and instructional methodologies (e.g. SCAMPER).
3. Regression Analysis: To determine which variables, such as motivation and personality traits, predicted an increase in creativity.
4. Thematic Analysis: To examine qualitative information from talks and interviews about using digital tools and creative growth.

In order to obtain a more comprehensive understanding of how innovative teaching methods impact student creativity and engagement, the study used a mixed-methods sequential explanatory design, which allows for a robust evaluation by quantifying educational impacts and enhancing these findings with qualitative insights. The study used a quasi-experimental design to quantitatively assess the impact of instructional methods on creativity using the TTCT. To further understand the student experience, thematic analysis was performed on qualitative data collected from Moodle discussions and project feedback.

Ethical considerations

Every participant gave their informed consent, guaranteeing anonymity and confidentiality throughout the data gathering procedure. The study complied with institutional ethical principles and upheld privacy, data security and participant rights standards.

Limitations

This study's restriction to university students may have limited its applicability to other demographics. Self-reported data created potential biases, and although the sample size was large enough, it might need to accurately reflect wider demographic differences.

Results

TTCT analysis

The students' creative thinking was assessed in four areas using the abbreviated TTCT for adults: fluency, originality, elaboration and flexibility. Participants in the exam, which lasted around 20 min, had to write and draw their responses to words and images. Table 4 presents a summary of the analytical outcomes from the pre- and post-test.

Following the completion of the SCAMPER teaching strategy and PBL, significant gains were seen in all four aspects of creativity. Students produced more creative answers and ideas, demonstrating increased fluency and originality. Their ability to elaborate and analyze analytically, as well as their adaptability in problem-solving, also significantly increased.

Based on their pre-test results, participants were further split into groups with high and low creativity, enabling an evaluation of the disparities in the effects of various tactics on students. The group with more creativity had significant improvements in fluency, exhibiting more frequent and fluid idea development. During conversations and projects, their capacity for creative problem-solving and multifaceted problem-solving significantly increased.

Table 4. Results for the TTCT pre-test and post-test.

Variable	*N*		*M*	SD	*t*	*p*
Fluency	150	Pre-test	19.8	8.29	0.006	0.00004
	150	Post-test	35.16	16.08		
Originality	150	Pre-test	22.77	4.63	0.005	0.00002
	150	Post-test	47.19	7.05		
Elaboration	150	Pre-test	22.89	4.43	0.003	0.00002
	150	Post-test	36.08	7.20		
Flexibility	150	Pre-test	22.59	4.63	0.003	0.00001
	150	Post-test	38.06	7.07		

Source: Author's development.

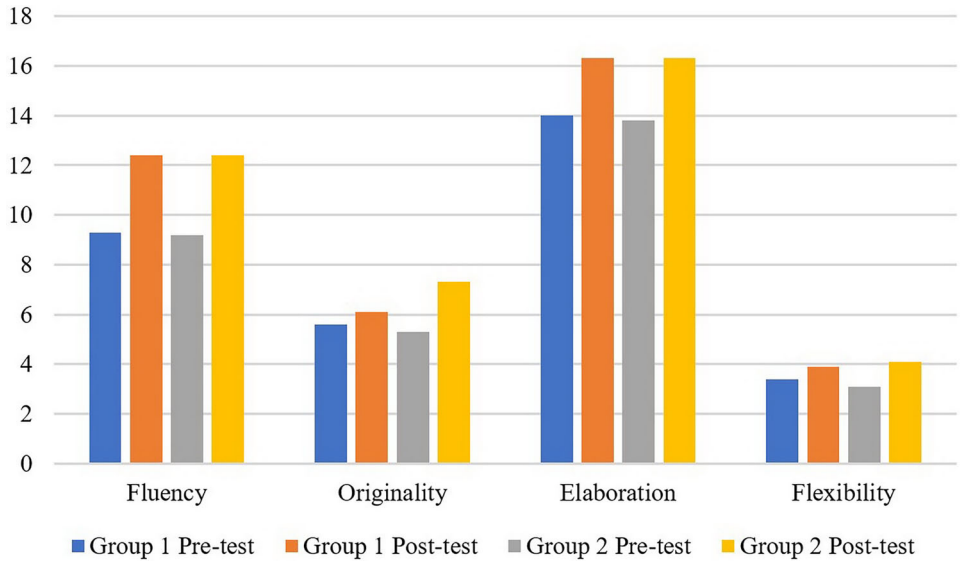

Figure 1. Comparison of pre-test and post-test creativity scores.
Source: Author's development.

Originality, elaboration and flexibility improved for learners with poor creativity as they eschewed inflexible thought patterns in favor of a more adaptable, open-minded mindset. Despite moving more slowly at first, they were nonetheless able to meaningfully expand and enhance their original concepts thanks to the SCAMPER technique.

Figure 1's statistical analysis demonstrates that the high-creativity group outperformed the low-creativity group in terms of improvements, especially in the areas of fluency and originality. Nonetheless, the PBL strategy benefited both groups, demonstrating the potency of fusing conventional pedagogies with methods that emphasize creativity.

Personality traits analysis

The personality test revealed information about the students' aspirations for success and methods of problem-solving. Students' capacity to overcome obstacles and apply SCAMPER and other creative thinking techniques to solve issues was assessed. Four major components of the personality traits were examined: achievement-oriented, flexible in problem-solving, self-efficacy, and collaborative involvement, as can be seen in Table 5.

Better achievement orientation and self-efficacy scores among students were associated with a greater commitment to project completion and better levels of creativity, especially in originality and elaboration. Higher problem-solving flexibility was accompanied by the capacity to switch between concepts, which was consistent with increased fluency and flexibility on the TTCT. On the other hand, students who scored lower on self-efficacy typically needed help coming up with original ideas and solving problems; their pre-test scores did not increase as much as their post-test scores did.

Students who demonstrated a high degree of collaborative engagement also showed higher degrees of flexibility and elaboration and were more inclined to participate actively in group discussions. Overall, there was a favorable correlation found between higher scores in fluency and creativity and personality qualities, including conscientiousness and openness to new experiences.

Work Preference Inventory (WPI)

Throughout the study, students' intrinsic and extrinsic motivation was assessed using the WPI. Students who find personal fulfillment in work or who have high intrinsic drive showed better overall creativity, especially in fluency and originality (Table 6). These students were more likely to use the SCAMPER

Table 5. Summary of personality traits and their impact on creativity.

Personality trait	Key dimension	Impact on creativity	Related TTCT dimensions	Observation
Achievement orientation	Goal commitment	Strong commitment to completing projects	Originality, elaboration	Students with high achievement orientation showed enhanced originality and elaboration.
Self-efficacy	Confidence in problem-solving	Greater success in creativity and problem-solving	Originality, elaboration	High self-efficacy was linked to better project outcomes and creative idea generation.
Problem-solving flexibility	Adaptability	Ability to switch between different ideas easily	Fluency, flexibility	Higher problem-solving flexibility led to better performance in fluency and flexibility.
Collaborative engagement	Teamwork and cooperation	Active contribution in discussions and teamwork	Flexibility, elaboration	Students with high collaborative engagement contributed to group projects more effectively.
Openness to experience	Creativity and exploration	More willing to explore new ideas and concepts	Fluency, originality	Openness to experience was positively correlated with higher fluency and originality.
Conscientiousness	Organization and discipline	Consistent project execution and attention to detail	Fluency, originality	Conscientious students showed higher scores in fluency and originality due to disciplined effort.
Low self-efficacy	Lack of confidence	Struggled with creativity and problem-solving	Lower creativity scores	Students with low self-efficacy exhibited minimal improvement from pre- to post-test results.

Source: Author's development.

Table 6. Work Preference Inventory (WPI) results.

Variable	*N*		*M*	SD	*t*	*p*
Fluency	150	Pre-test	3.06	1.48	0.00005	0.000
	150	Post-test	5.02	1.36		
Originality	150	Pre-test	2.11	0.84	0.00006	0.000
	150	Post-test	3.10	0.85		

Source: Author's development.

approach to investigate several options when working independently to solve problems. Additionally, they persevered longer while revising their products in response to criticism.

Conversely, students who were driven by extrinsic motivation, that is, by rewards or evaluations from outside sources, performed well on projects while exhibiting less originality, especially in elaboration. Their research tends to focus on meeting basic requirements rather than exploring new approaches. Although these kids benefited from group projects, they lacked the level of originality of their more motivated peers.

Group dynamics and collaboration

Students actively engaged in group discussions exchanged ideas and worked together on project presentations using the Moodle platform. Students were able to interact both formally and informally in this virtual setting, communicating either synchronously or in real time. These discussions were essential for determining the ways in which group dynamics and creative outputs were impacted by interpersonal and collaborative abilities.

- Strong Collaborators and Leadership Roles
  Students with excellent interpersonal and collaborative skills – often associated with higher levels of agreeableness and extraversion (as measured by personality questionnaires) – played crucial roles in

their groups, according to qualitative data from the conversations and group projects. These students were more likely to:

- Assume leadership responsibilities: They frequently took on roles of coordination within their teams, supporting the efficient management of conversations, goal setting and job delegation.
- Promote participation: By creating a welcoming and inclusive atmosphere, these students inspired others to think freely and creatively. Less talkative team members were encouraged to participate more actively by their good social effect.
- Encourage creativity: Their effective communication abilities made it easier for group members to share unusual and varied ideas, essential for coming up with original solutions to problems.

- Struggles with Collaboration

  Conversely, students who had trouble collaborating were less successful in group settings; these students were frequently associated with high levels of neuroticism or poor agreeableness. These students exhibited actions that impeded the creative development of both themselves and their group:
  - Limited contributions: During group conversations, students with high neuroticism frequently felt anxious or insecure, which prevented them from contributing fully to the creative process or sharing ideas. They become very dependent on others for ideas and approaches to problem-solving as a result of their hesitancy.
  - Less creative growth: Compared to their more involved counterparts, these students' creative thinking skills did not progress as much as they could since they did not participate as much. They were less exposed to a variety of viewpoints during conversations, which is crucial for the development of creative thinking abilities, as a result of their propensity to shun danger or disagreement.
  - Dependency on group members: These students frequently looked on the other members of the group for guidance rather than coming up with new ideas. Because of this dependence on more outspoken or aggressive group members, they were less likely to grow as problem solvers or to make a significant contribution to the project's results.
- Impact on Creative Output

Groups with higher degrees of cooperation, especially among students with excellent social and leadership abilities, regularly generated more innovative and well-rounded work, according to the examination of group dynamics. According to the TTCT post-test findings, these groups did exceptionally well in the categories of fluency, originality and elaboration.

On the other hand, organizations that needed more involvement or had less teamwork tended to do worse in terms of innovation. This discrepancy emphasizes how critical interpersonal skills are to creating a cooperative atmosphere that stimulates original thought and problem-solving.

The correlation study was to investigate the connections among students' motivation, achievement orientation, self-efficacy, and creative outputs as defined by fluency, originality, elaboration and flexibility. The results revealed significant positive relationships among these factors, suggesting that better creative scores are associated with stronger achievement orientation, higher motivation, and greater self-efficacy (Table 7). Additionally, the potential of self-efficacy, achievement orientation, and motivation to predict creative outcomes in fluency, originality, elaboration and flexibility was assessed using multiple regression analysis. Each predictor variable significantly contributed to the prediction of creative scores, with motivation showing the highest predictive value according to the regression models (Table 8).

The findings of the correlation study showed that students' motivation, achievement orientation, self-efficacy, and creative scores in fluency, originality, elaboration and flexibility were all strongly positively correlated. These results suggest that students are more likely to demonstrate greater creativity if they are driven, self-assured, and goal-oriented. This is consistent with psychological theories that contend that self-efficacy and intrinsic motivation are important factors influencing creative performance in learning environments. These results are corroborated by the regression analysis, which shows that motivation is a very powerful predictor of every aspect of creativity. This implies that student motivation-boosting interventions may be especially successful in fostering creativity.

Table 7. Correlation coefficients among study variables.

Variable	Self-Efficacy	Achievement Orientation	Motivation	Fluency	Originality	Elaboration	Flexibility
Self-efficacy	1	0.72	0.68	0.61	0.59	0.6	0.58
Achievement orientation	0.72	1	0.75	0.67	0.65	0.66	0.64
Motivation	0.68	0.75	1	0.7	0.68	0.69	0.71
Fluency	0.61	0.67	0.7	1	0.91	0.89	0.87
Originality	0.59	0.65	0.68	0.91	1	0.93	0.9
Elaboration	0.6	0.66	0.69	0.89	0.93	1	0.88
Flexibility	0.58	0.64	0.71	0.87	0.9	0.88	1

Table 8. Regression analysis results.

Dependent variable	Predictor	B Coefficient	Standard error	*t* Value	*p* Value
Fluency	Self-efficacy	0.31	0.05	6.2	<0.001
	Achievement orientation	0.29	0.05	5.8	<0.001
	Motivation	0.34	0.04	8.5	<0.001
Originality	Self-efficacy	0.27	0.04	6.75	<0.001
	Achievement orientation	0.25	0.04	6.25	<0.001
	Motivation	0.33	0.03	11	<0.001
Elaboration	Self-efficacy	0.26	0.04	6.5	<0.001
	Achievement orientation	0.24	0.04	6	<0.001
	Motivation	0.3	0.03	10	<0.001
Flexibility	Self-efficacy	0.28	0.05	5.6	<0.001
	Achievement orientation	0.27	0.05	5.4	<0.001
	Motivation	0.35	0.04	8.75	<0.001

Overall, the results point to the need to create an open, encouraging and supportive group atmosphere where students feel empowered to participate to improve creative performance in educational settings. Encouraging the development of interpersonal skills in addition to academic and creative ability can result in improved group project outputs and increased effectiveness in cooperation.

Discussion

The study's conclusions about the connections among creativity, personality qualities and teaching strategies are consistent with and build upon earlier findings. The use of the SCAMPER approach and PBL has led to notable enhancements in students' fluency, inventiveness, elaboration and flexibility. These benefits are consistent with worldwide trends in educational research. Active learning strategies like PBL have been demonstrated in recent research by Hao Yu to stimulate creativity in students by getting them involved in group problem-solving and critical-thinking exercises. In doing so, he looked at how well PBL supports creative thinking within educational frameworks and how well it aligns with psychological principles and cognitive functions to support creative abilities (Yu, 2024).

Our study's findings align with those of a study by Arfa Afzal, which emphasizes creative teaching as a potent modern learning instrument in higher education. Arfa Afzal's research also highlights that the challenges in implementing creative teaching techniques frequently stem from the imprecise definition, interpretation and nature of creativity. These challenges can lead to inconsistencies in the application of creativity across disciplines, particularly in more structured fields such as engineering and healthcare. On the other hand, adding new teaching exercises to the curriculum is beneficial. Similar to our findings, this research underscores how creativity enhances critical thinking, adaptability, and innovation while also improving students' problem-solving skills (Afzal et al., 2023).

According to our research, people become creative when fully engaged in activities that push their limits and present chances for development. This approach explains the favorable results of our study, in which students completed organized yet flexible activities that encouraged creativity by breaking problems down step-by-step. This idea is supported by Xhomara and Uka's study, which highlights the value of a supportive learning environment and instructional strategies in promoting creativity. According to both research studies, creativity flourishes in learning environments that encourage experimentation and offer the right amount of difficulty to get students thinking. Although creative education is the subject of both studies, ours focuses on Russian and Kazakh university students, particularly those studying computer science, engineering and medicine. In contrast, Xhomara and Uka's study examines

creativity in Albanian primary and secondary education. Given that various educational stages may call for different approaches to fostering creativity, this variability in the educational setting is important (Xhomara & Uka, 2022).

Our study's findings and those of Ezinne Chidinma Abe and Saturday Tete Birabil's research show a number of significant parallels and divergences, most notably in how creativity and critical thinking are incorporated into teaching methods. The significance of encouraging creativity and critical thinking in contemporary education is emphasized by both studies. Our study demonstrated that utilizing SCAMPER and PBL strategies greatly enhanced students' creative thinking. Similarly, Abe and Birabil emphasize that these cognitive abilities are critical for students' success in the twenty-first century, particularly in a society where social shifts and technological breakthroughs are the norm. In our study, the use of SCAMPER resulted in significant improvements in fluency, originality and elaboration, which aligns with Abe and Birabil's finding that critical thinking and creativity are enhanced when students are encouraged to explore multiple perspectives and engage in problem-solving (Abe & Birabil, 2022).

Comparing the findings of our study with that of Nurkhairo Hidayati, we find that both studies demonstrate a considerable increase in creativity when using organized learning approaches, such as SCAMPER in our study and integrated PBL with digital mind maps (DMM) in the other study. SCAMPER enhanced students' creativity in terms of fluency, originality, elaboration and adaptability, according to our research. Comparably, in the second study, the combination of PBL and DMM significantly increased creativity, especially in terms of originality, elaboration, and adaptability. The significance of critical thinking in the creative process is emphasized in both studies. It was discovered in the PBL-DMM study that critical thinking and creativity are complementary, with critical thinking aiding in the improvement and refining of creative ideas (Hidayati et al., 2019).

When we contrast our study's findings with those of Egana-delSol, we see that both investigations showed notable gains in creativity in a variety of areas. Fluency, originality and elaboration, as determined by the TTCT, significantly improved in our study when SCAMPER and PBL were used. Similar gains were made in creativity due to the art-based approach, especially in abstract thought and concept manipulation. Our research concentrated more on using SCAMPER and digital tools to foster creativity and solve problems in an organized manner. In contrast, the Chilean program took a more art-based approach that prioritized cultural and artistic endeavors. This led to different creative expressions – our study emphasized problem-solving and critical thinking. In contrast, the Chilean study focused on creative behaviors like producing cultural goods and engaging in artistic activities (Egana-delSol, 2023).

Comparing our findings with those of Doolotbai and Makhabat's study, we discovered that both investigations found a substantial increase in students' creative thinking as a result of active teaching strategies. Similar to Doolotbai and Makhabat's findings, the SCAMPER approach and PBL significantly improved the study's participants' fluency, originality and elaboration. Their research showed that by involving students in cognitive tasks that demand critical and creative thought, active learning strategies, including brainstorming, round tables and practical exercises, promote creativity. Although creativity is emphasized in both research, Doolotbai and Makhabat's study focuses more on cognitive development in addition to creativity. They explored how active learning methods also enhance students' ability to analyze facts, events, and phenomena with slightly broader cognitive focus compared to our study, which was primarily centered on creative thinking dimensions such as fluency and originality (Doolotbai & Makhabat, 2021).

Our research and that of Setiana Sitepu and Iyehezkiel Parudani both showed how innovative teaching strategies might improve student achievements. SCAMPER and PBL enhanced the creativity of our study in terms of fluency, originality and elaboration. Similar results were found in the study by Sitepu and Parudani, which demonstrated how creative pedagogies promote engagement and active learning. Students' motivation and self-confidence in speaking activities increased dramatically as a result of the creative approaches used. More generally, our study addressed problem-solving and creative thinking across a variety of academic fields, such as engineering and medicine. By contrast, the focus of Sitepu and Parudani's study was on enhancing conversational skills in the context of English language acquisition, with a particular emphasis on speaking fluently and confidently (Sitepu & Parudani, 2023).

Both our study and a study by Janaka Low and Lv Jinghua demonstrated how student-centered teaching strategies foster creativity. Both studies discovered that innovative teaching strategies and

active involvement increase student engagement. According to our research, Moodle and digital technologies encouraged communication and teamwork, which improved creative output. According to Jinghua and Low's research, students' practical skills and creativity were enhanced by group projects and hands-on activities, particularly when the projects linked theory and practice. Jinghua and Low emphasize the connection between instructional strategies and academic success more than other authors, contending that student-centered learning environments foster both academic success and creativity. Contrarily, our study focuses mainly on the growth of creativity without explicitly addressing academic accomplishment, which is an important divergence in the results' breadth (Jinghua & Low, 2022).

Conclusions

The study's findings support the strong beneficial effects of PBL and SCAMPER on students' creativity. According to the TTCT, students' fluency, creativity, elaboration and flexibility have significantly improved as compared to pre-test levels. Furthermore, there was a significant correlation found between creativity and personality factors, including self-efficacy, problem-solving flexibility and collaborative involvement. This finding highlights the significance of individual attributes in the learning process. The investigation goes on to show how interactive learning environments like Moodle, when paired with organized supervision, may greatly improve students' capacity for original problem-solving, especially when working in groups. This study is useful because it shows how creative teaching strategies may improve student results and encourage innovation. Teachers may learn how to effectively integrate conventional and new techniques of teaching by seeing how innovative teaching tactics include digital platforms like Moodle. From a scientific standpoint, this work contributes to the increasing research that demonstrates the connection between creativity and student-centered learning in higher education. It also advances our knowledge of the ways in which learning methodologies and personality variables interact to shape creative thinking. The research's conclusions are applicable to a wide range of academic subjects, especially those that call for critical and creative thinking, such as computer science, engineering and medical education. SCAMPER and PBL also help foster creativity in transdisciplinary domains where creative and cooperative thinking is essential. Subsequent research endeavors may investigate the enduring effects of these innovative pedagogical approaches on scholastic attainment and career viability. More studies might look at how these techniques can be modified for various cultural settings or combined with cutting-edge digital technology, such as AI-based learning tools, to further improve creative problem-solving abilities.

Ethics approval

The authors declare that the work is written with due consideration of ethical standards. The study was conducted in accordance with the ethical principles approved by the Ethics Committee of L.N. Gumilyov Eurasian National University (Protocol № 335 of 13.07.2023).

Informed consent

All research participants gave their written informed consent before the commencement of the research.

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Data availability statement

All data generated or analyzed during this study are included in this published article.

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