



The effect of Canva-assisted guided inquiry on students' creativity and conceptual understanding in environmental change learning: A quasi-experimental

Lida Amalia*, Rifaatul Muthmainnah, Siti Soviawati

Department of Biology Education, Faculty of Science and Applied Science, Institut Pendidikan Indonesia Garut, Garut, Jawa Barat, Indonesia

*Corresponding Author Email: lidaamalia@institutpendidikan.ac.id

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Abstract

In the 21st century, science education must not only promote conceptual mastery but also cultivate creativity and higher-order thinking skills to address global challenges such as sustainability and environmental change. However, students often struggle to connect scientific knowledge with real-world contexts, leading to fragmented understanding and limited opportunities for creative expression. This study investigates the effectiveness of guided inquiry assisted by Canva, in enhancing both conceptual understanding and creativity in environmental change learning. The novelty of this research is the use of Canva-assisted guided inquiry as an integrated approach to develop both higher-order conceptual understanding and creativity aligned with 21st-century learning demands. A quasi-experimental design with a one-group pretest-posttest model was implemented with 40 tenth-grade students in Garut, Indonesia. Data were collected through a conceptual understanding test and a creativity rubric applied to student-designed posters. The results indicated an improvement in conceptual understanding ($p < 0.001$, Cohen's $d = 3.48$, $N\text{-gain} = 0.63$, medium-category) and generally positive levels of creativity across most groups, particularly in relevance and originality. These findings suggest that Canva-supported guided inquiry provides a low-cost yet powerful pedagogical model that bridges cognitive and creative learning. The study contributes to theory by extending inquiry learning into digital platforms and to practice by offering scalable strategies for teachers. Future research is recommended to employ more comprehensive creativity assessments and to implement this approach across diverse educational contexts.

Abstrak. Pembelajaran sains abad ke-21 menuntut penguasaan konsep sekaligus pengembangan kreativitas dan keterampilan berpikir tingkat tinggi untuk menghadapi isu global seperti perubahan lingkungan. Namun, siswa sering kesulitan menghubungkan pengetahuan ilmiah dengan konteks nyata sehingga pemahaman menjadi terfragmentasi dan kesempatan berekspresi kreatif terbatas. Penelitian ini bertujuan menganalisis efektivitas inkuiri terbimbing berbantuan Canva dalam meningkatkan pemahaman konsep dan kreativitas siswa pada topik perubahan lingkungan. Kebaruan penelitian ini terletak pada penggunaan guided inquiry berbantuan Canva sebagai pendekatan terintegrasi untuk mengembangkan pemahaman konseptual tingkat tinggi dan kreativitas yang selaras dengan tuntutan pembelajaran abad ke-21. Metode yang digunakan adalah kuasi eksperimen dengan desain pretest-posttest satu kelompok pada 40 siswa kelas X di Garut. Data dikumpulkan melalui tes pemahaman konsep dan rubrik kreativitas untuk menilai poster yang dibuat siswa. Hasil penelitian menunjukkan adanya peningkatan pemahaman konseptual ($p < 0,001$; Cohen's $d = 3,48$; $N\text{-gain} = 0,63$ kategori sedang-tinggi) serta tingkat kreativitas yang secara umum positif pada sebagian besar kelompok, khususnya pada aspek relevansi dan orisinalitas. Temuan ini menegaskan bahwa Canva dapat menjadi media digital yang efektif, murah, dan mudah digunakan dalam mendukung inkuiri terbimbing. Penelitian ini berkontribusi pada teori dengan memperluas penerapan inkuiri ke platform digital serta pada praktik dengan menawarkan model pembelajaran yang relevan bagi tuntutan abad ke-21. Penelitian selanjutnya disarankan untuk menggunakan instrumen penilaian kreativitas yang lebih komprehensif dan menerapkan pendekatan ini pada konteks pendidikan yang lebih beragam.

A. Introduction

Current trends in science education increasingly emphasizes not only the mastery of scientific knowledge but also the development of higher-order thinking skills such as creativity, problem-solving, and conceptual understanding (Miterianifa et al., 2021). These competencies are critical for preparing students to address complex global challenges, including sustainability and environmental change (Calasang et al., 2025). However, the integration of these competencies into science education has often been inconsistent (López et al., 2024). While curricula may highlight the importance of environmental literacy, classroom practices frequently rely on teacher-centered methods and rote memorization (Petersen et al., 2020), leaving students with fragmented knowledge and limited opportunities to apply concepts meaningfully.

The urgency of addressing this issue is reinforced by international assessments. The 2022 Program for International Student Assessment (PISA) reported that Indonesian students scored below the OECD average in science, particularly in areas requiring critical and creative problem-solving (OECD, 2023). Similarly, another finding view that students often struggle when confronted with tasks requiring the integration of scientific reasoning, creativity, and real-world problem contexts (Laudia et al., 2023). These findings suggest that current pedagogical approaches do not adequately cultivate the skills needed to understand and act upon environmental issues. Beyond Indonesia, environmental education research underscores a worldwide challenge: students often perceive environmental change as abstract and disconnected from their daily lives, which hampers both their conceptual understanding and their motivation to engage with sustainability-related actions (Portus et al., 2024).

A preliminary classroom observation conducted by the researchers revealed similar patterns. When learning about environmental change, most students demonstrated difficulties in linking scientific concepts with real-world phenomena, such as climate variability or pollution. Their explanations tended to remain superficial, focusing on memorized definitions rather than analytical reasoning. Moreover, when asked to present their understanding creatively, students produced products that were largely descriptive with little evidence of critical insight or originality. These findings suggest that the current learning process provides insufficient scaffolding to simultaneously promote creativity and conceptual understanding.

Previous studies have echoed these findings. Researchers reported that students often struggle to integrate scientific principles with complex environmental issues, resulting in compartmentalized learning (Hakiki & Saputra, 2024). OECD highlighted that student performance in creative thinking tasks remains significantly lower than in memorization-

based tasks (Scherbakova et al., 2024). Daumiller et al. (2025) further noted that the absence of visual and digital tools in environmental science classrooms contributes to low engagement and limited conceptual mastery. Although advanced technologies such as augmented reality and simulations have been explored to enhance learning outcomes (Chang et al., 2025), fewer studies have investigated the role of accessible design tools like Canva in guided inquiry settings to cultivate creativity and deep conceptual understanding simultaneously.

Despite these insights, a significant research gap persists in identifying practical and scalable pedagogical strategies that simultaneously enhance creativity and conceptual understanding in environmental change learning. Other previous studies have employed advanced technologies such as augmented reality, virtual simulations, or complex digital platforms to improve student engagement and cognitive outcomes (Uygur et al., 2018). While these innovations demonstrate potential, they often require high costs, strong infrastructure, and advanced teacher training, making them less feasible in many classroom contexts, particularly in developing countries. At the same time, studies that focus on low-cost digital tools tend to emphasize either creative product development or conceptual comprehension, but rarely their integration. This indicates a lack of attention to accessible and teacher-friendly technologies that can achieve both outcomes. Therefore, exploring guided inquiry combined with Canva offers a novel and contextually relevant approach. Unlike high-end technologies, Canva provides a low-barrier entry point for teachers and students while still supporting creativity, visualization, and deep conceptual engagement.

Accordingly, this study aims to investigate the effectiveness of guided inquiry assisted by Canva in promoting students' creativity and conceptual understanding of environmental change. By addressing both cognitive and creative dimensions within a socio-scientific issue, the research not only supports but also extends existing literature on inquiry-based learning and technology integration.

This study adopts a constructive stance by building upon prior evidence of guided inquiry's cognitive benefits and Canva's creative affordances, while also addressing the gap in their combined application. The novelty of this research lies in demonstrating that accessible, low-cost digital tools can be strategically integrated into pedagogical models to achieve complex educational goals that are often associated with more sophisticated technologies. The research is guided by two central questions: (1) How does guided inquiry assisted by Canva influence students' creative thinking in learning environmental change? and (2) How does guided inquiry assisted by

Canva enhance students' conceptual understanding of environmental change?

B. Material and method

Research design

This study employed a quasi-experimental design with a one-group pre-test and post-test model. This design was considered appropriate because the main purpose was to measure the effect of guided inquiry learning assisted by Canva on students' conceptual understanding and creativity. This design may be subject to internal validity threats such as testing and maturation effects (Creswell, 2012). To mitigate these issues, equivalent test forms were used, the intervention was implemented within a short timeframe, and no additional instructional treatments were introduced during the study.

Participants

The population of the study consisted of tenth-grade students from a public senior high school in Garut, West Java, Indonesia. One intact class of 40 students was selected purposively as the research sample, representing the typical characteristics of learners in the school context. All participants engaged in the guided inquiry activities for two consecutive meetings on the topic of environmental change, with each meeting lasting 70 minutes.

Instruments

Two instruments were used to collect data:

- 1) Conceptual understanding test
 - a) Format: multiple-choice questions with five options.
 - b) Total items: 25, covering key indicators of environmental change.
 - c) Reviewed by two experts in biology education for content validity.
 - d) Validity testing using the Pearson Product-Moment correlation identified 27 valid items (67.5%), from which 25 items were selected for use in the pre-test and post-test.
 - e) The instrument demonstrated satisfactory validity and high reliability, with a reliability coefficient of 0.81 (Cronbach's Alfa), indicating strong internal consistency (for example see Table 1).
- 2) Creativity rubric for poster products
 - a) Dimensions assessed: originality, elaboration, flexibility, and aesthetic quality (Hadas & Hershkovitz, 2025).
 - b) Scale: 1 to 4 for each dimension.
 - c) Rubric development: adapted from Torrance's framework of creative thinking with adjustments for visual product assessment (Owen & Roberts, 2024).
 - d) Reviewed by expert in biology education for validity (see Table 2).

Procedures

The research was conducted in three phases:

- 1) Pre-test: Before the intervention, students completed the conceptual understanding test to establish baseline knowledge.
- 2) Learning Intervention: Students participated in guided inquiry learning, which included the following stages: (a) orientation to the environmental change issue, (b) problem formulation, (c) data collection and exploration, (d) organizing findings using Canva, and (e) presentation and reflection. During the process, students designed posters in Canva as the main creative product (Annisa et al., 2025).
- 3) Post-test and Product Assessment: After the intervention, the same conceptual understanding test was administered, and student posters were collected and evaluated using the creativity rubric.

Data analysis

Data analysis was carried out in two streams:

- 1) Conceptual understanding: Pretest and posttest scores were analyzed at the individual level ($n = 40$). Prior to inferential analysis, a statistical assumption test was conducted. Data normality was examined using the Shapiro-Wilk test, as the sample size was fewer than 50 participants. Descriptive statistics (mean, standard deviation, minimum-maximum, and normalized gain) were computed. Inferential analysis was conducted using a paired-samples t-test to examine significant improvement (Justice et al., 2019).
- 2) Creativity: Poster creativity was analyzed at the group level ($n = 8$). Each poster was evaluated using the creativity rubric (Xu et al., 2025), and mean scores across dimensions were calculated. Results were reported descriptively, supported by examples of student posters to illustrate creative variations. everyday experiences with scientific inquiry. Students were encouraged to respond with relevant examples, such as deforestation, improper waste disposal, or large-scale burning, thereby contextualizing the upcoming investigation. In the core learning phase, the five stages of guided inquiry were systematically implemented. First, during orientation, the teacher presented Canva-based materials containing ecosystem-related content and posed a problem scenario for students to analyze. Students were invited to identify issues and propose initial ideas. Second, in hypothesis formulation, students, working within their groups, constructed tentative answers based on prior knowledge and reading tasks. To scaffold this process,

Table 1 Example of conceptual understanding test items on environmental change

No	Example item	Cognitive level
1	Indicator: Explaining the impact of global warming on ecosystems Global warming is the increase in the Earth's average surface temperature. Which of the following is an impact of global warming on ecosystems? a. Loss of land and sinking ecosystems b. Increasing cases of forest fires c. Lower temperatures in the equatorial regions d. Disruption of the food chain e. Food crises both on land and at sea	C2 (Understanding)
2	Indicator: Identifying preventive actions against environmental damage The best way to prevent forest fires is... a. Cutting down all trees for industrial areas b. Avoiding careless burning during the dry season c. Maintaining water reserves in case of fire d. Throwing cigarette butts carelessly e. Large-scale deforestation to avoid fires	C3 (Applying)
3	Indicator: Analyzing the causes of soil ecosystem changes The soil ecosystem consists of air, water, minerals, organic matter, and organisms that interact closely. Which of the following is not a factor causing changes in the soil ecosystem? a. Forest fires b. Factory emissions c. Excess non-organic waste d. Liquid and solid industrial waste e. Movement of the Earth's plates	C4 (Analyzing)

Table 2 Scoring for creativity rubric

Aspect	Score 4	Score 3	Score 2	Score 1
Originality	Very unique ideas, highly innovative	Some unique ideas, moderately original	Few new ideas, mostly conventional	No originality, very common
Relevance	Content fully matches topic and message	Mostly relevant, minor off-topic elements	Partly relevant, some unrelated parts	Not relevant to topic
Clarity & design	Very clear message, attractive and well-structured	Clear message, good design	Message partly clear, design less neat	Unclear message, messy design
Visual appeal	Excellent use of colors, images, layout	Good use of visuals, minor issues	Limited use of visuals, less engaging	Poor visuals, unattractive

C. Results and discussion

Implementation of guided inquiry with Canva

This study aimed to examine (1) the effect of guided inquiry assisted by Canva on students' conceptual understanding of environmental change and (2) the level of students' creativity as reflected in poster products.

The results are gained through the learning process that was conducted in several phases following the syntax of the guided inquiry model, with Canva integrated as a digital learning medium. Prior to the lesson, students were organized into collaborative groups consisting of six to seven members. The session began with preliminary activities, including greetings, attendance checking, and a pretest designed to assess students' initial conceptual understanding of environmental change. This stage was also used to cultivate students' readiness for learning and to establish classroom routines that supported character education.

The lesson proceeded with an introductory phase, in which the teacher activated students' prior knowledge by asking guiding questions such as "Can human activities damage ecosystems?". This discussion served as an entry point to connect everyday experiences with scientific inquiry. Students were encouraged to respond with relevant examples, such as deforestation, improper waste disposal, or large-scale burning, thereby contextualizing the upcoming investigation. In the core learning phase, the five stages of guided inquiry were systematically implemented. First, during orientation, the teacher presented Canva the teacher distributed worksheets (LKPD) that guided students in articulating predictions, such as the impact of illegal logging on biodiversity and environmental stability.

The third stage involved data collection, where students engaged in literature exploration to gather relevant information that could support or challenge their hypotheses. At the fourth stage, data analysis, groups synthesized their findings and presented emerging patterns during class discussions. The

teacher facilitated this exchange by prompting students to connect evidence with their initial assumptions. Finally, in the conclusion stage, groups used Canva to compile and visually communicate their results in the form of posters. These products not only captured their conclusions about ecosystem change but also reflected their creativity in transforming abstract concepts into visual messages. Groups then

presented their posters to the class, fostering peer-to-peer learning and critical dialogue.

The session concluded with reinforcement of key concepts, the administration of a posttest to measure learning gains, and a reflection phase guided by the teacher. The closing activities emphasized consolidation of knowledge while maintaining the structure of guided inquiry.

Table 3 Summary of pretest and posttest scores

Statistic	Pretest	Posttest
Mean	50.70	81.80
Standard deviation	6.98	9.23
Minimum	36	64
Maximum	64	96

Table 4 The score of students' creativity

Group	Total Score	Category
G1	13	High
G2	16	High
G3	12	Moderate
G4	14	High
G5	14	High
G6	11	Moderate
G7	15	High
G8	11	Moderate

Table 5 The mean score for each creativity aspect

Aspect	Mean score (1-4)
Originality	3.25
Relevance	3.50
Clarity & design	3.13
Visual appeal	3.38
Total (max 16)	13.25

Conceptual understanding

Students' conceptual understanding was measured using a 25-item test administered before and after the intervention. Table 3 shows the descriptive statistics of pretest and posttest scores.

As shown in Table 3, the average pretest score was 50.70 (SD = 6.98), indicating that students' prior conceptual understanding of environmental change was relatively low. After the intervention, the mean posttest score increased to 81.80 (SD = 9.23), with the minimum and maximum scores also improving substantially. This suggests that the guided inquiry approach supported by Canva effectively enhanced students' mastery of the targeted concepts.

The paired-samples t-test confirmed that the difference between pretest and posttest scores was statistically significant, $t(39) = 21.99$, $p < 0.001$. The effect size (Cohen's $d = 3.48$) was categorized as very large, indicating that the intervention produced a substantial educational impact. In addition, normalized gain analysis (N-gain = 0.63) showed a medium-to-high level of improvement, suggesting that the majority of students progressed considerably in

their conceptual understanding. Taken together, these findings provide strong evidence that guided inquiry integrated with Canva was successful in fostering students' conceptual learning about environmental change.

The statistical analysis showed that students' mean posttest scores improved significantly compared to their pretest scores ($M = 81.80$ vs. 50.70), with a large effect size (Cohen's $d = 3.48$) and a medium-to-high normalized gain (N-gain = 0.63) (Table 3). This result indicates a positive tendency in students' conceptual development following the implementation of guided inquiry integrated with Canva. From a theoretical perspective, this improvement aligns with constructivist principles, where learners actively build knowledge through inquiry processes (Pratiwi et al., 2025). Guided inquiry enabled students to engage in hypothesis formulation, data analysis, and evidence-based reasoning, which are key mechanisms for deepening conceptual understanding (Suryati et al., 2024).

The role of Canva as a scaffolding tool was also critical. Visual representations helped students

transform abstract concepts of environmental change into concrete, communicable forms (Hannigan et al., 2025). This is consistent with Safitri et al. (2025), who emphasized that inquiry learning supported with external representations strengthens students' mental models and promotes knowledge retention. Similarly, Zafeer et al (2025) found that integrating digital tools into science classrooms enhances engagement and comprehension. Taken together, these findings reinforce the argument that low-cost, user-friendly technologies like Canva can serve as effective cognitive scaffolds in guided inquiry contexts.

For practice, this suggests that teachers can leverage guided inquiry combined with Canva to address persistent gaps in students' science learning. By enabling students to visualize complex processes, teachers can facilitate not only memorization of definitions but also the meaningful application of concepts to real-world issues.

Despite these positive outcomes, several limitations should be considered when interpreting the findings. The use of a one-group pretest-posttest design limits causal inference, as improvements in conceptual understanding may also be influenced by testing effects, maturation, or increased familiarity with the content rather than the intervention alone. Without a comparison group, it is not possible to fully disentangle the specific contribution of Canva-assisted guided inquiry from other instructional or contextual factors. Consequently, the results should be interpreted as indicative rather than conclusive evidence of effectiveness.

In addition, the strong effect size observed in this study should be interpreted cautiously. While guided inquiry has been widely reported to enhance conceptual understanding, some studies have shown more modest or mixed effects, particularly when inquiry activities are insufficiently scaffolded or when students have limited prior knowledge (Chengere et al., 2025). These contrasting findings suggest that the effectiveness of inquiry-based approaches is highly contingent on instructional design quality, teacher guidance, and learner characteristics, rather than the inquiry model or digital tools alone.

Furthermore, although Canva functioned effectively as a visual and cognitive scaffold in this study, its impact may vary across contexts. Research has shown that digital tools can sometimes increase cognitive load if learners focus more on design features than on underlying scientific concepts (Koć et al., 2022). Therefore, the positive role of Canva observed here should be understood as context-dependent and closely tied to structured guidance and clear learning objectives.

Creativity in poster products

Students' creativity was assessed through group poster projects created with Canva. Each of the eight groups was evaluated using a rubric covering

originality, relevance, clarity & design, and visual appeal. The detailed scores are presented in Table 4, while Table 5 summarizes the mean performance for each creativity aspect

As shown in Table 4, five groups (62.5%) achieved high creativity, while three groups (37.5%) achieved moderate creativity. No group fell into the low category, indicating that Canva-supported guided inquiry successfully stimulated creative expression across all groups. Table 5 further illustrates the performance in each aspect. The highest-rated aspect was Relevance ($M = 3.50$), suggesting that students' posters were strongly aligned with the learning objectives and effectively conveyed messages about environmental change. Originality and Visual Appeal also showed relatively high scores (3.25 and 3.38, respectively), reflecting students' ability to generate unique ideas and apply design elements in creative ways. The lowest score was observed in Clarity & Design ($M = 3.13$), indicating that some groups still experienced challenges in structuring information and ensuring that their posters communicated messages with maximum clarity. Overall, the mean total score across groups was 13.25 (out of 16), which falls into the high creativity category. This finding highlights that the integration of Canva into guided inquiry not only improved students' conceptual understanding but also fostered their creative thinking skills through visual communication tasks.

In terms of creativity, the majority of student groups achieved high scores in their poster products, with an average total score of 13.25 out of 16 (Table 4; Table 5). The highest-performing aspect was relevance ($M = 3.50$), while clarity and design received relatively lower ratings ($M = 3.13$). This pattern indicates that students were able to connect their products strongly to the topic but still faced challenges in organizing and refining their visual communication.

Theoretically, guided inquiry fosters divergent thinking by allowing students to explore multiple solutions and represent their ideas creatively. When coupled with Canva, students were provided with a platform to express originality and aesthetic appeal in their work (Sugiarni et al., 2024). This resonates with Torrance's framework of creative thinking, which highlights originality, elaboration, and flexibility as key components. Furthermore, prior studies in project-based science learning have similarly reported that open-ended tasks encourage students to move beyond rote learning and produce more innovative outputs (Pinar et al., 2025). Research on digital tools also supports the finding that technology integration expands opportunities for students to develop and demonstrate creativity (Bereczki & Kárpáti, 2021).

In practical terms, these results imply that Canva not only supported cognitive engagement but also extended the scope of inquiry learning to include affective and creative domains. Teachers may therefore consider assessing students' creative

products as valid indicators of learning outcomes in addition to traditional cognitive tests. However, creativity gains are not an automatic outcome of inquiry or digital integration. Prior studies have shown that overly constrained inquiry tasks or insufficient guidance may limit creative expression, while poorly designed digital activities can shift students' attention toward visual appeal rather than conceptual understanding (Al-kfairy et al., 2025).

Taken together, the findings suggest that guided inquiry with Canva creates a synergistic effect between conceptual understanding and creativity. Students were not only learning "to know" but also learning "to create," bridging the cognitive and creative dimensions of science learning. This dual outcome represents a novel contribution, as most prior studies have typically focused on either cognitive gains or creative outcomes in isolation. By showing that a simple, low-cost tool like Canva can facilitate both outcomes within an inquiry framework, this research addresses a critical gap in the literature on inquiry-based pedagogy and digital integration.

Despite its advantages, the use of Canva as a learning support tool also presents notable limitations. Canva's emphasis on templates and visual design may constrain deeper scientific reasoning if students prioritize aesthetics over conceptual accuracy. Several studies have reported that design-oriented digital tools do not necessarily enhance learning outcomes and may even reduce conceptual focus when learners devote excessive cognitive resources to layout and visual elements rather than to scientific meaning-making (Fitzgerald & Evans, 2024). In contrast to the positive findings of this study, research by Sailer et al (Sailer et al., 2024) found that technology-enhanced inquiry did not yield significantly higher conceptual gains compared to non-digital inquiry when instructional scaffolding was limited. These contrasting results suggest that Canva's effectiveness is not inherent to the tool itself but depends on how explicitly it is integrated into inquiry structures, learning objectives, and assessment criteria. Consequently, Canva should be viewed as a conditional scaffold whose pedagogical value emerges only when supported by clear conceptual guidance and purposeful instructional design.

The contribution of this study can be considered on three levels. Theoretically, it enriches the understanding of guided inquiry by demonstrating its adaptability to digital platforms in ways that promote both cognitive and creative dimensions of learning. Practically, it offers teachers an accessible model of integrating Canva to support inquiry processes, thus enhancing students' engagement and broadening the scope of assessment to include creativity. At the policy level, the findings support science education frameworks trends such as PISA's emphasis on creative and critical thinking, as well as the SDGs that call for environmental literacy and innovation. Future

research could therefore expand the sample size, diversify the measurement of creativity, and explore cross-context applications of guided inquiry with Canva in different subject areas.

D. Conclusion

This study provides preliminary evidence of improvements in students' conceptual understanding of environmental change and creativity in learning activities supported by Canva-assisted guided inquiry. The findings contribute theoretically by extending inquiry-based learning into digital contexts that support both cognitive and creative outcomes, and practically by offering teachers a low-cost and scalable instructional model for science classrooms. Teachers are encouraged to integrate Canva within clearly structured inquiry phases, ensuring that design activities are explicitly aligned with conceptual learning objectives and supported by assessment rubrics that balance scientific accuracy and creativity. To strengthen the robustness and generalizability of the findings, future research should involve larger and more diverse samples, include comparison groups, and employ broader measures of creativity beyond visual products alone.

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