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Brief Communication

Effects of ChatGPT use on undergraduate students' creativity: a threat to creative thinking?

Radu Bogdan Toma[1] · **Iraya Yánez-Pérez**[1]

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Abstract
Concerns have arisen regarding the potential negative impact of long-term ChatGPT use on creative thinking. This study investigates these effects using a one-group, pretest–posttest design involving 31 undergraduates over a 10-week intervention period. Participants used ChatGPT to complete academic assignments focused on designing teaching units on bacterial growth, chronic disease, and the human body. Creativity was assessed using the CREA-Creative Intelligence test, a valid and reliable instrument. Data were analyzed using both frequentist and Bayesian methods. The results showed that 25% of participants experienced decreased creativity, 21.43% remained unchanged, and 53.57% showed improvement. Overall, the study found no evidence that ChatGPT negatively impacts creative thinking.

Keywords Artificial intelligence · ChatGPT · Creativity · Education · Large language models

1 Introduction

ChatGPT is a generative Artificial Intelligence (AI) chatbot powered by a large language model (LLM). Its public release in late November 2022 initiated an unprecedented journey for the educational system [1, 2]. While the use of AI in the educational landscape has gained attention in recent years [3], previous chatbots have been limited to predetermined and simplistic conversational structures [4]. ChatGPT, however, has overcome these limitations. It can engage in human-like interactions, generating contextually appropriate responses to a diverse range of user requests [5, 6]. For example, ChatGPT has been found to align with key research themes in science education and has proven helpful in designing evidence-based science units, rubrics, and quizzes [7]. Its capabilities extend far beyond [2].

Nevertheless, critical voices express caution regarding the use of ChatGPT in education [8]. Concerns have been raised about cheating and compromised academic integrity [9], untruthfulness and misleading information [5, 10], reinforcement of biases and stereotypes [7], and doubts about the quality and inclusiveness of the training data used [11]. Amidst issues related to ChatGPT use, one caution emerges as particularly noteworthy: over-reliance, which may limit opportunities to foster creativity [6]. This concern relies on the intuitive assumption that excessive use may stifle creativity: "If ChatGPT does everything or many things for students and professors, it may also kill creativity" [2], p. 25]. AI overreliance risks replacing active thinking with passive consumption of information intake. Creative thinking requires independent thought for idea generation, exploring diverse perspectives, and independently solving problems [12, 13]. Indeed, the

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✉ Radu Bogdan Toma, rbtoma@ubu.es | [1]Faculty of Education, Department of Specific Didactics, University of Burgos, Burgos, Spain.

use of teaching methodologies focused on problem-solving tasks can improve creativity [14]. Relying on ChatGPT for answers may limit the opportunity for students to engage deeply with complex concepts, establish connections between ideas, or provide solutions on their own. In this sense, in their Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis of ChatGPT, Farrokhnia et al. [15] signaled ChatGPT as a potential threat to higher-order cognitive skills, such as creativity, due to the simplified process of obtaining answers and information. In the same vein, educational technology experts emphasize the importance of individuals developing their creative potential and imagination before using generative AI, like ChatGPT [11]. Similarly, Kikalishvili [1] underscores the significance of LLM for the learning process, yet asserts that it cannot replace educators' role in fostering creativity among students.

Creativity is a vital component of educational policy. Existing research demonstrates its positive impact on economic and cultural growth [16]. As the world becomes increasingly complex, creativity is essential for addressing the 21st-century's challenges. However, the availability of ChatGPT is hypothesized to pose a threat to the development of creativity. Indeed, a recent study found a significant decline in students' creative writing ability as a result of using ChatGPT [17]. On the contrary, students who used ChatGPT to solve a complex creative problem outperformed those who did not [18]. However, both studies were relatively short experiments conducted under controlled conditions, with ChatGPT being used for less than an hour in each case. Thus, the assumption that prolonged (i.e., semester-long) use of ChatGPT for academic tasks might impact students' creativity is still yet to be explored. Therefore, this study pursues such an endeavor.

The theoretical underpinning of the study is grounded in the contemporary conceptualization of creativity as a set of cognitive abilities necessary for producing novel and useful ideas or products [19, 20]. Creativity is a complex construct. It is viewed as a higher-order thinking process that can be learned and developed. Indeed, previous research indicates that various interventions can enhance creativity. A 12-week problem-based learning session [14], a 25-day intervention using programming tools like Scratch [21], and an eight-week program in cooperative learning environments [22] have all been shown to foster creativity. However, the concept of creativity is multifaceted and subject to varying definitions across different fields of study. A comprehensive review of 600 articles on creativity research [12] found that while definitions vary, most emphasize uniqueness/novelty (73%) and divergent thinking (51%). These findings align with classic definitions, such as Sternberg's [23], which posits that creativity involves "thinking that is aimed at producing ideas or products that are relatively novel and that are, in some respect, compelling" (p. 2). Therefore, this study adopts a definition of creativity that emphasizes novelty as a core aspect of the creative process. Consequently, the measurement of creativity is grounded in divergent thinking, which involves generating multiple novel ideas and solutions [13].

1.1 Aim and research question

This study investigates the potential negative impact of ChatGPT use on undergraduate creativity. It examines the relationship between ChatGPT as an academic tool and creativity development. Specifically, the study explores whether using ChatGPT for coursework and assignments over ten weeks might hinder creativity development. The research question is:

- Does the use of ChatGPT for completing academic assignments during a 10-week intervention negatively impact the creativity of undergraduate students?

2 Method

2.1 Study design and procedure

This study used a one-group, pretest–posttest design [24], in which the creativity of all participants was evaluated before and after an intervention comprising the use of ChatGPT for the completion of academic tasks over 10 weeks. The intervention lasted ten weeks, consisting of one weekly session of two hours, for a total of 20 h. Participants were instructed on ChatGPT, its educational potential, and general and basic guidelines for use. In the initial session, students were introduced to various potential uses of ChatGPT. This first session aimed to familiarize students with ChatGPT and its basic functions, rather than instructing them on its optimal use. For example, participants learned the importance of clear and specific prompts and the need to break down complex requests when interacting with ChatGPT. They also explored various examples of tasks that ChatGPT can perform, such as text summarization and simplification. They were presented with demonstrations on designing lesson plans from diverse prompts (e.g., writing a lesson plan about the food pyramid for 4 years old students), generating ideas for teaching activities, discussing educational issues (e.g.,

teaching methodologies or classroom management strategies) with ChatGPT, and summarizing and rewriting texts or activities adapted to different educational levels.

Then, for the remaining sessions, students completed three assignments related to the early childhood science curriculum, comprising 40% of the course grade (Fig. 1). For the first assignment, students used ChatGPT (v. 3.5) –following specific prompts and instructions (see Supplementary File)– to reflect on inquiry-based science teaching methodology, gather tips and best practices, and design and conduct inquiry units on bacterial growth. Specific prompts and instructions were provided for the first task to ensure that participants learned the basic features of ChatGPT. For the subsequent tasks, students were given the freedom to use ChatGPT independently. The remaining two assignments involved developing and presenting a dissemination activity on chronic diseases and creating a teaching unit explaining the human body. In these assignments, students freely used ChatGPT for inspiration, information retrieval, and guidance for presentations.

To provide more concrete examples of the intervention, part of the first task is next explained. The Supplementary File contains the student worksheet and teacher instructions. The task consisted of four steps. First, participants reflected on the challenges and barriers they perceived in using inquiry-based science teaching in early childhood education. Second, they used ChatGPT to discuss these challenges and barriers and receive evidence-based advice. Participants formulated questions to ChatGPT using provided prompts. Third, they reflected and took notes on the key ideas, best practices, and recommendations from ChatGPT. In addition, they wrote a key takeaway paragraph summarizing the advice and best practices for each challenge or barrier discussed with ChatGPT. Finally, participants completed a reflection form about the relevance, difficulty, emotions, attitudes, abilities, skills, and contextual factors related to inquiry-based methodology.

The study was conducted during the second semester of the 2022–2023 academic year. The increasing use of ChatGPT by undergraduates limited the use of a reliable control group. Ensuring the internal validity of the study would have required preventing these students from accessing ChatGPT or any similar LLM. While access can be controlled in short experiments, doing so over 10 weeks with students using personal computers was impractical and raised ethical concerns. For example, one of the tasks was to develop a didactic unit about bacterial growth, which spanned several sessions. Although the use of ChatGPT by a control group could have been controlled during face-to-face sessions, it would have been impossible to ensure they would not use it outside of class to complete this task. Additionally, it would have been impossible to control their use during other subjects of the university degree.

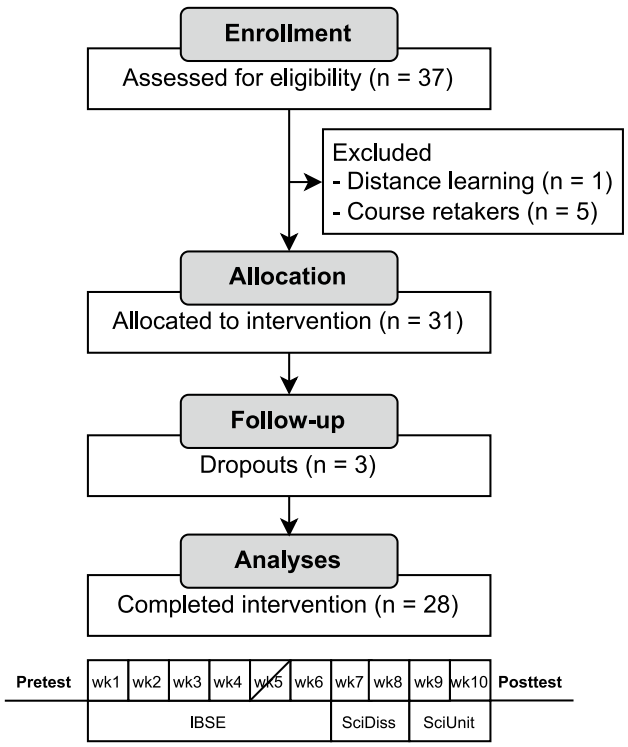

Fig. 1 CONSORT-SPI participants flow diagram [25]

2.2 Participants

Since this study is an initial exploration into the effect of LLM reliance on creativity, non-probability convenience sampling was used. Thirty-seven undergraduates enrolled in a pre-service kindergarten degree program at a Spanish university were assessed for eligibility (Fig. 1). One student was excluded due to participation in a distance learning modality, and five were excluded for being course retakers who only needed to take the final exam. Of the 31 participants assigned to the intervention, three did not complete all tasks and were excluded. Consequently, 28 undergraduates completed the intervention and were included in the data analysis. Most participants were female ($n = 25$, 89.29%) with a mean age of 21.93 ($SD = 1.80$). At intervention allocation, 10 participants (35.71%) were unfamiliar with ChatGPT, 16 (57.14%) were aware but untested, and 2 (7.14%) had limited experience. This study was performed in line with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The procedures were approved by the Ethics Committee of the University of Burgos. Informed consent was obtained from all individual participants included in the study. The participants have consented to the publication of the findings of this study. In addition, they were informed that the results of the creativity test would not affect their grades. Participants were debriefed after the post-test.

2.3 Instrument

The CREA—Creative Intelligence [13] test was used to assess participants creativity. The CREA is a test for measuring creative intelligence. Specifically, it assess individuals' ability for generating novel and original ideas, known as divergent thinking. Participants are presented with visual stimuli and asked to formulate questions based on the images within a limited 4-min timeframe. Each question activates a new cognitive schema, providing a measure of creativity. The visual stimuli is a complex image that depicts a dynamic setting with multiple elements, hence providing numerous opportunities for cognitive exploration and schema activation.

This test was specifically designed and psychometrically validated for Spanish-speaking population, and is considered one of the most valid and reliable measures of creativity for this demographic, justifying its selection in this study [13]. Furthermore, the CREA is used internationally, with studies confirming its validity and reliability across diverse sociocultural contexts, including Argentina, the United States, Israel, Poland, Mexico, and Turkey [26]. Additionally, research found that the CREA has convergent validity with the Torrance Test of Creative Thinking, reinforcing its use as a measure of creativity [27].

The test comprises three different versions (images A, B, or C), with only one being used per evaluation according to participants age. In this study, image C was chosen due to the stronger evidence of validity. Specifically, image C was found to have the greatest concurrent ($r = 0.81$) and predictive (65% of variance explained) validity with the Guilford creativity test [13, 28]. In this study, the CREA was administered according to standardized procedures: participants completed it individually in a paper-and-pencil format, without any assistance from ChatGPT or other devices.

2.4 Data analyses

Participants' responses to the CREA test were assessed in accordance with the standard procedure. One point was awarded per valid question, except for repetition or unrelated questions (e.g., What? When? How?). Double questions (e.g., Is the handle used for charging the phone or as a prize dispenser?) were awarded two points. Two experienced raters, familiar with the CREA test, scored all data after an initial meeting where they scored 20% of the pretest valid data (5 questionnaires) together. Subsequently, each rater independently evaluated all remaining data, and inter-rater agreement was then calculated. The two-way, mixed-effects Intraclass Correlation Coefficient on the absolute agreement was 0.985 (95% CI 0.967–0.993) for the pretest and 0.984 (95% CI 0.965–0.992) for the posttest, suggesting excellent reliability for the data analysis [29], and in line with previous research on the CREA test [13, 14]. Discrepancies between the two raters were resolved through mutual agreement.

Based on the concerns raised in the literature that were discussed above, the hypothesis tested is $H0$: "Participants' creativity does not decrease after using ChatGPT for academic-related assignments" against the alternative $H1$ of a decrease in creativity. To provide a nuanced interpretation of the results, data analysis followed a comprehensive two-stage approach, beginning with a frequentist and subsequent Bayesian analysis based on established guidelines [30]. First, the Shapiro–Wilk test revealed a significant violation of normality for pretest scores ($W_{pretest} = 0.902$, $p = 0.012$), but

not for the posttest scores ($W_{posttest} = 0.936$, $p = 0.086$). Log-transformation was attempted with success ($W_{pretest} = 0.935$, $p = 0.084$; $W_{posttest} = 0.957$, $p = 0.294$). Therefore, frequentist and Bayesian one-tailed, paired sample *t*-test was conducted on the log-transformed data. Second, frequentist and Bayesian matched pairs Wilcoxon signed-rank test on the raw data were conducted. This was done to confirm that the log-transformation of the data did not impact the findings, hence providing robustness to the conclusions [25].

Given the lack of existing background knowledge regarding the effect size of ChatGPT on creativity, a default Cauchy prior of 0.707 was used. Jeffreys' cutoff values informed the interpretation of the Bayes Factor [30]: 1–3 (anecdotal evidence), 3–10 (moderate evidence), > 10 (strong evidence), and > 30 (very strong evidence). All analyses were performed on JASP 0.17.2.1 [31].

2.5 Statistical power

A priori power analysis using G*Power software indicated that a sample size ranging from 14 to 29 participants would be sufficient to detect medium to large effect sizes ($d = 0.5$–0.8) with 80% power and a one-tailed alpha. Therefore, the study is adequately powered.

3 Results

The data for this study are available at https://doi.org/10.17605/OSF.IO/C8AGN.

Figure 2a shows the results of the frequentist paired-samples *t*-test, indicating a non-significant difference between pretest and posttest scores, $t(27) = -3.222$, $p = 0.998$, $d = -0.609$, 95% CI [− 0.943, ∞]. Figure 2b reports the results of the frequentist Wilcoxon test on raw data, also indicating a non-significant difference in creativity, $W = 45.5$, $z = -2.630$, $p = 0.997$, effect size = − 0.640 [− 0.821, ∞]. Examination of ranks revealed that 25% of participants experienced a decrease in creativity (1 question less), 21.43% of participants remained at the same level, and 53.57% of participants exhibited improvement (1–4 more questions).

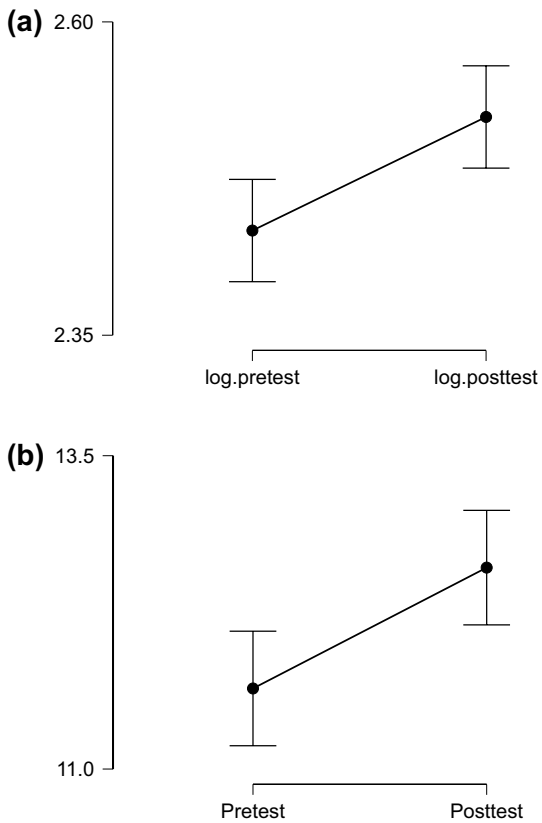

Fig. 2 Frequentist results

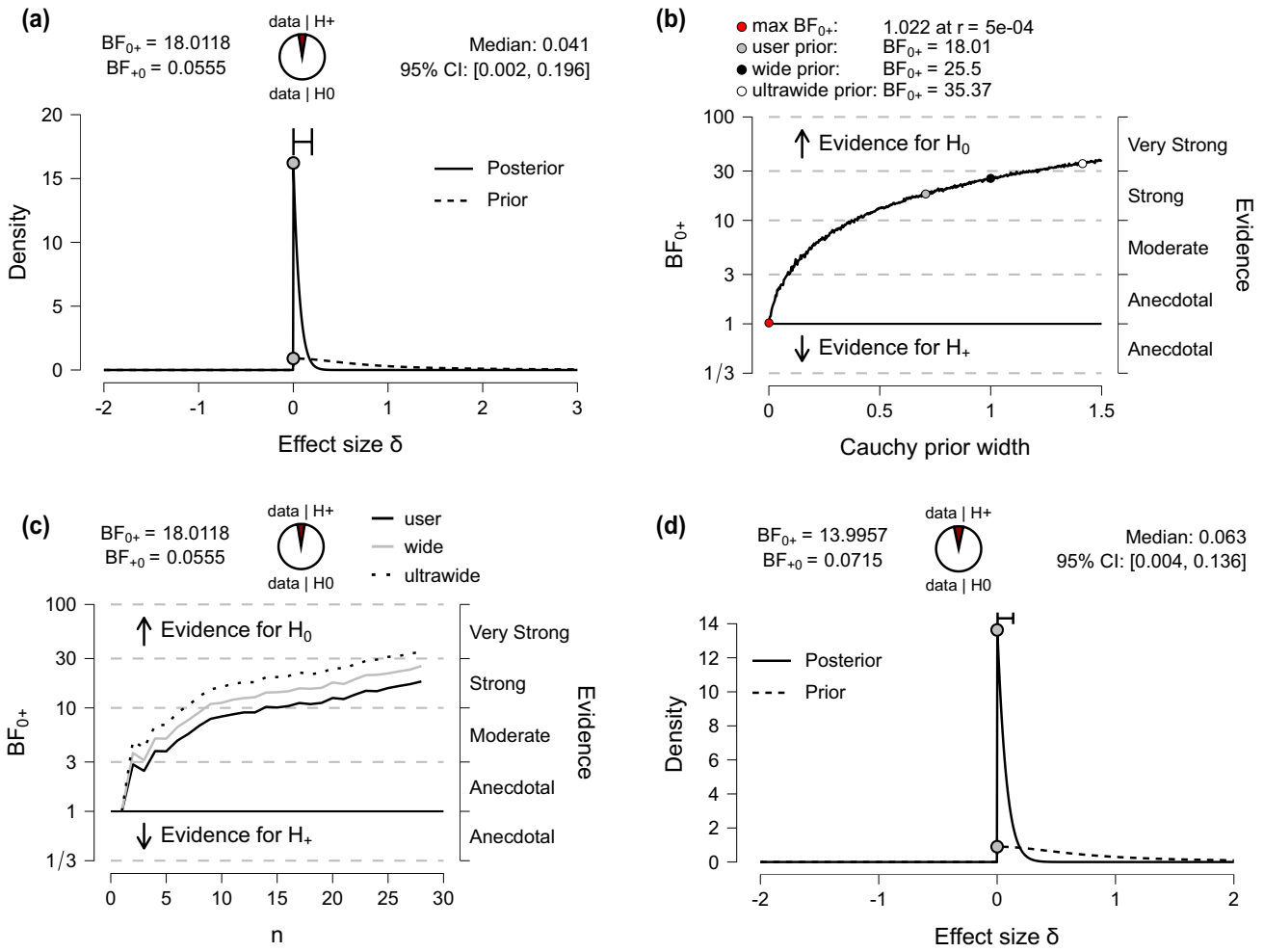

Fig. 3 Bayesian results

The Bayesian paired-samples *t*-test shown in Fig. 3a yields $BF_{o+} = 18.012$, indicating strong evidence for *H*0. The prior-posterior plot shows that with 95% probability, the true effect size δ is in [0.002, 0.196] and the posterior median is 0.041, indicating a small effect; this means that the data are approximately 18 times more likely to occur under the *H*0 rather that under the *H*1 hypothesis. These findings provide evidence for the H0 hypothesis stating that participants' creativity does not decrease after using ChatGPT for academic-related assignments.

The robustness check in Fig. 3b indicates that findings hold when different priori distribution widths are used; even when changing the priori, the Bayer factor indicated moderate to very strong evidence for *H*0. This indicates that the influence of the prior is minimal, and the analysis involves a negligible amount of subjectivity. Moreover, the sequential analysis in Fig. 3C shows increasing evidence for *H*0 against *H*1 as the number of data points increases; at 5 datapoints, evidence for *H*0 was moderate, while from 15 datapoints onward, it became strong. This also suggests little benefit to collecting a larger sample; with $n = 15$, there is strong evidence for not rejecting *H*0. Finally, the Bayesian Wilcoxon test on raw data from Fig. 3B also yielded strong evidence for *H*0, with $BF_{o+} = 13.996$. Therefore, these findings confirm that the H0 hypothesis cannot be rejected and therefore, participants' creativity does not decrease after using ChatGPT for academic-related assignments.

4 Discussion

The over-reliance on LLM has raised concerns about its potential negative impact on human creativity [2]. Consequently, ChatGPT, arguably the most popular LLM chatbot, has been regarded as both a powerful tool and a potential drawback in the field of education [11]. The purpose of this study, therefore, was to investigate the

impact of using ChatGPT on undergraduates' creativity. Based on extant literature [2, 6, 15], this study tested the hypothesis that the use of ChatGPT would decrease creativity levels. A two-process analysis revealed no negative impact of extended ChatGPT use on creativity. Specifically, the frequentist method provided a conventional analysis and revealed a non-significant difference in creativity scores following the intervention. The subsequent Bayesian approach addressed uncertainties and provided probabilistic interpretations, all suggesting that the null hypothesis of no negative impact on creativity could not be rejected. Taken together, this study failed to find evidence supporting the assertion that the use of ChatGPT for academic assignments decreases creativity levels. By adopting this sequential procedure, the depth and comprehensiveness of the analysis were improved; this leads to richer information about the research findings [32].

An unexpected finding was that over half of the participants experienced a negligible increase in their creativity levels, despite the intervention not using specific techniques known to improve creativity, such as De Bono's Six Thinking hats [33] or other cognitive-based creativity training techniques, like SCAMPER [20]. While the design of this study prevented drawing causal inferences for such an improvement, it does highlight potential avenues for future research on the effect of LLM chatbots on creativity development.

These are timely and relevant findings since the implications of over-reliance on chatbots powered by LLM for human creativity are signaled as a pressing issue [2, 6]. Previous studies tested the short-term impact of ChatGPT use on creative writing ability [17] and creative problem-solving [18]. However, this study focuses on the use of ChatGPT over a long period, suggesting that the use of ChatGPT over 10 weeks does not adversely affect the creative thinking abilities of undergraduate students. These findings have important educational implications. They highlight the need for educators, institutions, and policymakers to refrain from banning LLM technology based on untested threats. Instead, ethical considerations should be considered. Therefore, educators may consider incorporating LLM technology into curricula to support undergraduates with tasks and learning assignments. Given that the study did not find a negative impact on creativity from using ChatGPT over ten weeks, programs can explore the use of structured long-term projects that require students to engage with LLMs.

As ChatGPT becomes more integrated into educational settings, future research should investigate the ethical implications of its use, such as academic integrity [5, 9]. Another line of research worth endeavoring is the potential dependency on ChatGPT for cognitive tasks. Such studies are necessary to develop guidelines that ensure the responsible and ethical use of ChatGPT and similar AI tools in educational environments [6, 10]. Similarly, future research should adopt a more process-oriented approach. Existing studies have primarily focused on product-based metrics, such as the originality of ideas generated using ChatGPT [17, 18]. However, it could be interesting to also examine the cognitive processes involved while interacting with ChatGPT.

The findings of this study should be interpreted considering the following limitations. First, as a pilot study using convenient sampling, it is prone to selective bias. While this sampling method can be valuable for preliminary or exploratory research, offering initial insights and generating hypotheses, the generalizability of the findings is compromised. In addition, the gender imbalance in the sample limits the generalizability of the results to male pre-service teachers. Thus, further studies using probabilistic sampling techniques are encouraged. However, it should be noted that the sample size was large enough to reach valid conclusions. In this sense, the power analysis indicated an adequate sample size, supported by Bayesian robustness checks, showing no harmful effect of ChatGPT on creativity even with samples of 5 to 15 cases.

Second, a one-group, pretest–posttest design was the only feasible option, given the ubiquitous use of ChatGPT. As mentioned, the use of a control group was virtually impossible as contamination bias could arise from the difficulty of preventing control participants from using ChatGPT. However, several factors mitigate the concern over the learning effect. First, the substantial time interval between the pretest and posttest (10 weeks) reduces the likelihood of participants recalling specific answers from the initial assessment. Second, the nature of the CREA test, which is brief and does not have predetermined correct answers, minimizes the possibility of memorizing responses.

Despite its limitations, this study offers useful and novel insights into the effects of ChatGPT on the creativity of undergraduate students. Future studies focusing on the different cognitive processes of creativity, like fluency, flexibility, originality, and elaboration, could provide a valuable direction for further inquiry. Likewise, studies using alternative assessment methods, including both written and figurative/drawing tasks, are warranted to further explore the effect of LLM use on different aspects of creativity.

5 Conclusion

This study aimed to investigate the potential impact of using ChatGPT for 10 weeks, a popular LLM chatbot, on undergraduate students' creativity. Contrary to the hypothesis, the results indicated that the use of ChatGPT did not decrease creativity levels among the participants. These results challenge concerns about the over-reliance on ChatGPT and its potential drawbacks in education.

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Data availability The data that support the findings of this study are available at https://doi.org/10.17605/OSF.IO/C8AGN.

Declarations

Competing interests The authors declare no competing interests.

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