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Research Article

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Cultivating creative minds: An online math course's impact on Chinese students during the COVID-19 pandemic

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ABSTRACT

This study examines the implementation and outcomes of an online mathematics course designed to foster creative and critical thinking among six Chinese 10-year-olds during the COVID-19 pandemic. Delivered by an Israeli educator, the course focused on problem-solving tasks that encouraged independent and original thinking in a cross-cultural, remote learning context. The research addresses two primary questions: how online math courses can enhance creative thinking and the challenges of implementing such courses in culturally diverse settings. Initial challenges, such as cultural hesitancy to engage in creative exercises, were addressed through carefully structured tasks blending logical reasoning with creativity. This approach resulted in significant improvements in students' problem-solving abilities and positive attitudes toward STEM fields. A qualitative analysis of student feedback and solutions underscores the potential of online education to not only replicate but also enhance traditional learning experiences, particularly when adapted to the cultural contexts of learners. The findings highlight the importance of culturally responsive teaching and the integration of creative elements into mathematics curricula to foster higher-order thinking skills. This study provides practical recommendations for educators and policymakers while identifying key avenues for future research on the long-term impact of creative online learning and its application across diverse educational contexts.

Keywords: creative and critical thinking, problem-solving, distance learning

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INTRODUCTION

The COVID-19 pandemic brought unprecedented changes to education, disrupting traditional teaching methods and accelerating a global shift toward online and remote learning. This crisis not only transformed how educators teach and students learn but also created new opportunities for collaboration through digital platforms. Nearly 1.6 billion learners across more than 200 countries experienced disruptions to their education during this time, marking the largest educational crisis in modern history (Pokhrel & Chhetri, 2021). Amid these challenges, innovative online learning strategies emerged, enabling educators to transcend geographical barriers and share best practices globally. In this context, Israeli mathematics educators leveraged digital platforms to deliver culturally responsive and creative problem-solving courses to students worldwide.

This study focuses on an online mathematics course designed to foster creative and critical thinking skills in young learners. Delivered in weekly sessions over three months via Zoom, the course involved six Chinese 10-year-olds taught by an Israeli educator. The unique cross-cultural nature of the course exemplifies the potential of digital tools to enable global cooperation, support innovative educational practices, and enhance cognitive skills in diverse settings (Karakose, 2021).

East Asian countries, including China, are renowned for their success in international academic assessments such as TIMSS, PISA, and the international math olympiads. However, there is growing recognition within these systems of the need to shift from traditional methods emphasizing rote memorization to approaches fostering creativity and critical thinking. This shift is essential for preparing students for future careers in rapidly evolving science, technology, engineering, arts, and mathematics (STEAM) fields (Pokhrel & Chhetri, 2021).

The project described in this study aligns with these educational trends by introducing a course aimed at fostering creative and critical thinking through mathematics problem-solving. Conducted via Zoom, the course emphasized key 21st century skills, including creativity, communication, and collaboration. It also sought to cultivate positive attitudes toward STEAM subjects by increasing student engagement, self-efficacy, and interest (Bybee, 2013; National Research Council, 2014). By engaging young learners in challenging, open-ended tasks, the course aimed to develop diverse problem-solving approaches critical for academic and socioemotional success (Claessens & Engel, 2013).

Research consistently demonstrates that early-grade mathematics education benefits from curricula extending beyond basic skills to

include reasoning and discovery. Rich, open-ended, and challenging tasks play a key role in developing higher-order thinking abilities (Freiman, 2006; Krutetskii, 1976; Sheffield, 1999). Early exposure to these tasks not only builds foundational STEAM knowledge but also equips students with skills for deeper learning in later stages (Klibanoff et al., 2006).

While prior studies highlight the effectiveness of traditional problem-solving methods in math education, little is known about the role of online platforms in fostering creativity and critical thinking, especially in culturally diverse settings. This study seeks to address this gap by exploring the implementation and outcomes of an innovative online course.

METHODOLOGY

This study employed a qualitative case study design to explore the impact of an online mathematics course on fostering creative and critical thinking among young learners in a cross-cultural context. The study focused on a single cohort of six Chinese 10-year-old students over three months. Data were collected through recorded Zoom sessions, homework submissions, and observations of student interactions and problem-solving approaches. This design provided an in-depth understanding of the processes and outcomes associated with the course.

The course was delivered in 12 weekly one-hour sessions conducted via Zoom. Each session followed a structured format designed to encourage creativity and critical thinking:

1. **Warm-up activity:** Sessions began with engaging exercises to stimulate curiosity and prepare students for the core task.
2. **Core problem-solving task:** Students worked on challenging problems that required logical reasoning and innovative thinking. Tasks were carefully selected to balance cognitive demand and accessibility.
3. **Collaborative discussion:** Students shared their solutions and strategies in a group setting, fostering communication and exposure to diverse perspectives.
4. **Individual assignments:** Homework tasks reinforced session content and encouraged independent exploration.

The study employed a qualitative case study approach to evaluate student engagement, creative outputs, and problem-solving strategies. According to Yin (2018), a qualitative case study is particularly suitable for exploring complex phenomena in their real-world context. Data sources included recorded sessions and homework submissions, which were analyzed to identify patterns in creative thinking, problem-solving behaviors, and changes in student confidence throughout the study. Specific metrics included:

1. **Creativity:** Assessed through originality and diversity of solutions.
2. **Critical thinking:** Evaluated by the depth of reasoning and reflection in responses.
3. **Engagement:** Measured through participation in discussions and willingness to tackle open-ended problems.

The course design incorporated culturally responsive teaching strategies to address the unique needs of the students. For example, a bilingual Chinese coordinator supported communication and helped bridge cultural nuances. The timing of sessions, scheduled for 7 PM Beijing time, ensured that students were relaxed and ready to engage fully. Parents were encouraged to observe sessions, creating a supportive home environment without intervening directly in the learning process.

This methodology enabled a holistic evaluation of the course's impact, providing insights into the effectiveness of online platforms in fostering creative and critical thinking skills in a culturally diverse setting.

The research questions guiding this study are:

1. How does an online math course influence creative thinking among young learners?
2. What challenges and opportunities arise when implementing such a course in a cross-cultural context?

PROJECT DESCRIPTION

The online mathematics course was designed with the primary goal of fostering creative and critical thinking in young learners. The course drew on established educational principles that emphasize creating a supportive and stimulating learning environment. Key strategies for nurturing creativity, as outlined by Mangal (2007), were central to the course design and included:

- encouraging freedom to respond while eliminating fear of mistakes,
- instilling self-responsibility and teaching students to learn from errors,
- creating an atmosphere conducive to creative expression,
- providing stimulation and encouragement for originality and flexibility,
- leveraging community resources to inspire creative problem-solving, and
- promoting sensible risk-taking in tackling challenging tasks.

The educator, who also served as a role model for creative thinking, utilized these principles to inspire and guide students throughout the course.

The course was developed in response to observations by the Chinese coordinator, who noted that while students had strong foundational mathematical skills, they struggled with creative and critical thinking. The course sought to address these gaps by designing activities that were both culturally sensitive and intellectually stimulating. It aimed to encourage independent exploration, innovative problem-solving, and deeper engagement with mathematical concepts.

The program included diverse problem-solving tasks to foster creativity and critical thinking. Tasks were carefully selected to:

- reflect on students' daily experiences, making them relatable and engaging,
- encourage students to approach problems from multiple perspectives,
- inspire the creation of original problems by the students themselves, extending the learning process beyond class time, and
- integrate topics such as inquiry-based learning, math games, real-life applications, and spatial reasoning.

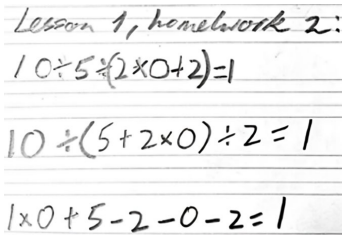

Figure 1. "Date problem" posed by a student (Source: Author)

A key feature of the course was its culturally responsive design. For instance, a bilingual Chinese coordinator supported communication during sessions, ensuring that linguistic or cultural barriers did not hinder participation. Additionally, sessions were scheduled at a time that accommodated the students' daily routines, fostering a calm and focused learning environment. Parents were encouraged to observe the sessions, further reinforcing a supportive home environment.

One of the course's defining characteristics was its iterative approach to learning. Students were encouraged to revisit and refine their solutions, reflecting on their thought processes and exploring alternative strategies. This approach not only deepened their understanding of mathematical concepts but also cultivated a mindset of innovation and persistence.

As the course progressed, a notable transformation in student engagement was observed. Initially hesitant to participate actively, students gradually became more comfortable sharing ideas and engaging in discussions. This change was attributed to the stress-free and supportive environment, which emphasized exploration over perfection. Homework assignments played a significant role in reinforcing concepts and fostering creativity. Students regularly submitted their work via email, and exemplary solutions were discussed in subsequent sessions to inspire further exploration.

The program's holistic approach to integrating creativity with logical reasoning laid the foundation for a dynamic learning experience. The following section illustrates how these principles were practically applied through specific examples, highlighting the progression of students' creative and critical thinking abilities.

Examples From One Unit

At the beginning of each lesson, students were tasked with creating new problems using the date of that day. For instance, on 10 May 2021, they were asked to generate problems without altering the order of the digits in the date (10.5.2021). **Figure 1** shows the "date problem" posed by a student.

One student came up with the following problem:

> "What is the next nearest date that can be written using the same seven digits?"

Another problem posed was:

> "What is the next nearest date where all the digits are different?"

These tasks served as warm-up exercises to stimulate the students' creativity and engagement before delving into more complex problems.

One of the core tasks introduced in the lesson involved a classic problem-solving scenario:

> A group of four individuals needed to cross a narrow bridge, but only two could cross at a time. The individuals had different crossing times–1 minute, 2 minutes, 5 minutes, and 10 minutes. When crossing together, the pair would take the time of the slower individual. Additionally, there was only one lamp, which needed to be carried back and forth, meaning someone had to return it to those waiting to cross. The challenge was to devise a plan to get everyone across in the shortest possible time (for the general case of this problem see Backhouse, 2008).

The teacher, who had previously used this problem with various audiences ranging from elementary school students to professional mathematics educators, observed different approaches based on the group. Israeli students, for example, often looked for unconventional solutions, such as leaving the lamp in the middle of the bridge or suggesting that a faster person carry a slower one. In contrast, older participants typically employed trial and error, coupled with some degree of analysis.

After a brief discussion, the ten-year-old Chinese students proposed a plan for crossing the bridge (**Table 1**).

The students were confident that this was the optimal plan. However, when the teacher asked if it was possible to reduce the total crossing time, the students were unsure. The teacher seized this moment to enhance their metacognitive skills by prompting them to reconsider their choices. The initial logic, which dictated pairing the fastest individual (1) with the slowest (10), seemed sound but was, in fact, flawed.

To challenge the students further, the teacher asked them to consider how much time each pair saved under their plan. This led to the realization that while pairing 1 and 10 saved one minute, pairing 5 and 10 would save a more substantial five minutes. With this insight, the students revised their strategy, resulting in the optimal plan (**Table 2**).

This exercise highlighted the discrepancy between intuitive and correct solutions, teaching the students to consider all possibilities and examine problems from different perspectives.

After solving the problem, the teacher shared an insightful question from an eight-year-old Israeli student:

> "How can you pass the lamp if someone is responsible for it? You can't just pass it along."

Table 1. The student's initial plan for crossing the bridge

Who crosses the bridge?	Time (in minutes) spent crossing the bridge	Who has already crossed the bridge?
1 and 10 =>	10 min	10
1 <=	1 min	
1 and 5 =>	5 min	5 and 10
1 <=	1 min	
1 and 2 =>	2 min	1, 2, 5, and 10
In total	19 min	

Table 2. The optimal plan for crossing the bridge-I

Who crosses the bridge?	Time (in minutes) spent crossing the bridge	Who has already crossed the bridge?
1 and 2 =>	2 min	1 and 2
1 <=	1 min	
5 and 10 =>	10 min	2, 5, and 10
2 <=	2 min	
1 and 2 =>	2 min	1, 2, 5, and 10
In total	17 min	

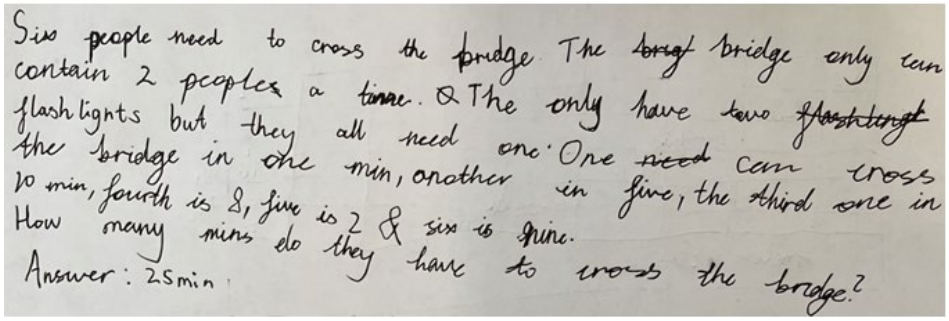

Figure 2. "Bridge problem" posed by a student (Source: Author)

Table 3. The optimal plan for crossing the bridge-II

Who crosses the bridge?	Time (in minutes) spent crossing the bridge	Who has already crossed the bridge?
1 and 2 =>	2 min	1 and 2
1 <=	1 min	
1, 5, and 10 =>	10 min	1, 2, 5, and 10
In total	13 min	

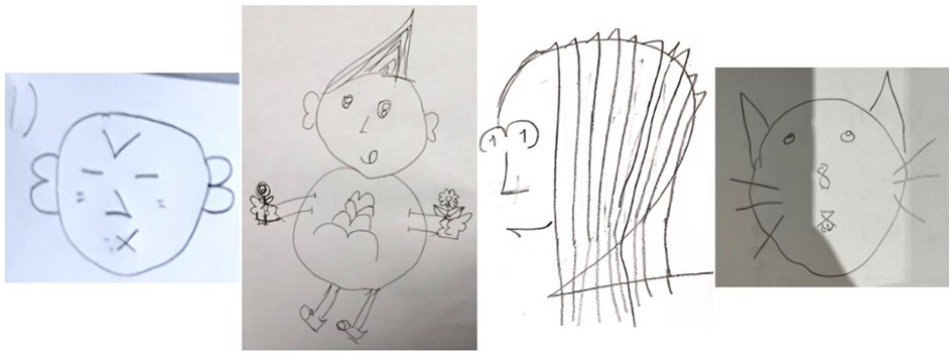

Figure 3. Students' pictures using numbers and arithmetic signs (Source: Author)

This question opened up a broader discussion on the balance between leveraging life experiences in problem-solving and adhering strictly to the problem's constraints. While life experience can be valuable, it's crucial not to let it divert from the mathematical essence of the task. This example underscored the importance of teacher flexibility and the ability to foster creativity without losing sight of the core learning objectives.

Following the core task, students were assigned homework to further explore these concepts. They were asked to:

- adjust the crossing time for one person so that the optimal time of 17 minutes remains unchanged,
- explore if it is possible to adjust the crossing times for two people while still achieving the optimal 17-minute crossing time, and
- create a new problem inspired by the bridge-crossing task, with the flexibility to change elements while maintaining the challenge.

Figure 2 shows a new problem posed by one of the students.

Another student suggested keeping the original problem' rules, but to allow 3 people to cross the bridge together.

The students' solution which was based on the same idea like in the original problem also worked. His plan was given in **Table 3**.

Additionally, to reinforce their learning and integrate creativity into mathematics, the teacher encouraged students to draw self-portraits using numbers and arithmetic signs, resulting in imaginative and personalized representations of themselves. Some of the student's works are presented in **Figure 3**.

Another task in this lesson involved a scenario where Linda and Liza each had five friends. They decided to throw a party and invite all their friends. The students were asked to determine how many children

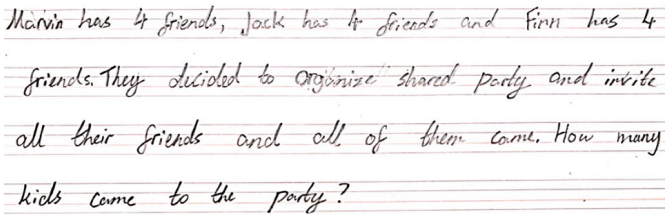

Figure 4. "Party problem" posed by a student (Source: Author)

attended the party. Initially, the students confidently answered 12, assuming no overlap between the two groups. However, they were surprised to learn that the actual number could vary depending on the overlap between Linda's and Liza's friends. The correct answer ranged from 7 (if all friends were shared) to 12 (if none were shared). This exercise taught the students the importance of considering multiple solutions and the variables that affect them.

The students were then encouraged to pose new problems based on the same concept, which were discussed in the next lesson. **Figure 4** shows a new problem posed by one of the students:

Finally, the lesson included a regular segment titled "What does that mean?" In this exercise, students were shown an image of a building and asked to guess its purpose. They were given a clue suggesting that the answer was not what they might intuitively expect. This activity encouraged them to think creatively, challenge assumptions, and explore unconventional possibilities, fostering a mindset of curiosity and open-ended problem-solving.

These examples not only illustrate the practical application of the course's design but also offer insights into the students' cognitive development throughout the sessions. The following discussion will analyze these outcomes in the context of broader educational trends and the specific challenges faced in fostering creative thinking through online learning.

DISCUSSION

The findings of this case study underscore the significant potential of online education to foster creative and critical thinking skills among young learners, particularly within the global shift to remote learning prompted by the COVID-19 pandemic (Karakose, 2021; Pokhrel & Chhetri, 2021). This study demonstrates how an online format can effectively engage students in creative problem-solving, even in a cross-cultural setting, aligning with the broader educational transformations necessitated by the pandemic.

A key observation from the project was the initial hesitation of Chinese students to engage in creative tasks. This reluctance reflects broader cultural tendencies in East Asian education systems, which traditionally emphasize precision and the avoidance of errors over exploratory learning. Similar findings have been highlighted in research examining the cultural influences on learning, where high uncertainty avoidance in some cultures can hinder students from engaging in open-ended problem-solving (Hofstede, 2001). However, this study highlights the ongoing shift in these systems toward more innovative and critical approaches to problem-solving. Through consistent encouragement and the creation of a supportive, non-judgmental environment, the students became increasingly comfortable expressing ideas and exploring diverse solutions. This shift underscores the importance of fostering a learning atmosphere that values freedom of thought and embraces trial and error as integral to the learning process (Pokhrel & Chhetri, 2021).

The study further revealed that, with the right tools and environment, students developed sophisticated problem-solving strategies that extended beyond rote memorization. For example, the bridge-crossing task illustrated how students initially relied on intuition but, with guided instruction, refined their approach to arrive at an optimal solution. This finding supports prior research showing that exposure to complex, open-ended tasks enhance higher-order thinking skills (Freiman, 2006; Krutetskii, 1976). Such tasks encourage students to explore multiple perspectives and challenge preconceived notions, contributing to the development of critical and creative problem-solving abilities (Klibanoff et al., 2006).

The integration of creative tasks within the mathematics curriculum–such as creating self-portraits using numbers and arithmetic signs–highlighted the value of combining artistic creativity with logical reasoning. This approach not only made the learning process more engaging but also helped students perceive mathematics as a dynamic and creative discipline rather than a rigid set of rules. This aligns with the broader goals of STEAM education, which aim to integrate technical skills with creative thinking to prepare students for future challenges in STEM fields (Karakose, 2021). As Perignat and Katz-Buonincontro (2019) note, blending creativity with traditional subjects can bridge the gap between theoretical knowledge and practical application, fostering a more comprehensive understanding of key concepts.

The cultural responsiveness of the course played a critical role in its success. By acknowledging and adapting to the cultural context of the students–through measures such as involving a local coordinator, scheduling sessions thoughtfully, and providing bilingual support—the course effectively engaged the participants. This adaptability aligns with broader research emphasizing the importance of cultural inclusivity in online education, particularly when addressing diverse linguistic and learning needs (Garrison, 2016; Reeve & Deci, 1996). The study reinforces the necessity of cultural adaptations to foster creative and critical thinking effectively across various educational settings (Pokhrel & Chhetri, 2021).

Nevertheless, the study identified challenges that future implementations must address. One challenge was ensuring consistent engagement from all students, especially in an online environment where quieter students may remain passive. Previous studies have noted that cultural factors, such as collectivist tendencies, may influence participation levels in group settings, requiring tailored approaches to engagement (Huang & Wang, 2019). Another challenge was balancing the need for structured learning with the flexibility required to foster creativity. The teacher's ability to navigate these challenges was crucial, suggesting that future courses would benefit from enhanced professional development in online pedagogy and cultural competence (Karakose, 2021; Reeve & Deci, 1996).

While the online format provided accessibility and introduced a novel approach to problem-solving, it also posed challenges such as maintaining consistent engagement and addressing technical issues. Additionally, the study's small sample size and reliance on qualitative observations limit the generalizability of its findings. Comparative research examining online versus face-to-face learning contexts could further illuminate the strengths and weaknesses of each approach, particularly in fostering creative and critical thinking.

Building on these insights, the next section explores the practical implications for educators and policymakers. These recommendations aim to guide the design and implementation of future online courses, particularly those intended to enhance creative and critical thinking in diverse educational settings.

Implications for Future Practice

The findings of this study offer several actionable implications for educators and policymakers seeking to enhance creative and critical thinking through online education.

First, online courses designed to foster creativity, and critical thinking must prioritize creating environments where students feel safe to experiment and make mistakes. Incorporating open-ended tasks that allow for multiple solutions and encouraging exploration and reflection are key strategies. As demonstrated in this study, a supportive and non-judgmental atmosphere is vital for building student confidence and engagement, particularly in settings where cultural norms may discourage risk-taking.

Second, educators must account for cultural differences and tailor their approaches to align with students' backgrounds and experiences. This can involve adjusting communication styles, integrating culturally relevant examples, and offering bilingual or additional language support when necessary. The success of the bilingual coordination in this study highlights the importance of cultural responsiveness in fostering inclusive and effective online education.

Third, integrating creative tasks within traditional mathematics curricula can significantly enhance engagement and deepen understanding. Blending creative arts with STEM disciplines fosters a holistic approach to learning that aligns with STEAM education goals and equips students with the skills needed for multifaceted challenges in the modern world. For instance, tasks that combine logical reasoning with artistic expression, as implemented in this study, make learning both engaging and impactful.

Finally, educators and institutions must invest in professional development for teachers to enhance their ability to foster creativity and critical thinking in virtual settings. Equipping educators with the tools to manage cultural nuances and adapt to online pedagogies is essential for maximizing the potential of remote learning environments.

While these recommendations provide practical insights for immediate application, further research is needed to fully understand the long-term impact of such interventions. The following section explores potential directions for future investigation.

Suggestions for Further Research

This study highlights several avenues for future research to expand upon its findings and address its limitations.

First, longitudinal studies are necessary to examine the long-term impact of online creative thinking courses on students' cognitive development, academic performance, and career trajectories. Such research would provide valuable insights into whether the skills cultivated in these courses have enduring effects.

Second, future research should explore the applicability of these findings across diverse age groups, subject areas, and cultural contexts. By expanding on the cross-cultural insights gained in this study, researchers can identify universal strategies for fostering creativity and critical thinking while also addressing context-specific adaptations.

Third, an important area of inquiry is the role of teacher training in the success of online creative thinking courses. Investigating how professional development programs can enhance educators' skills in fostering creativity and managing cultural dynamics in online classrooms would offer valuable guidance for policymakers and institutions. Research could also evaluate the effectiveness of specific teacher training models in achieving these goals.

Finally, comparative studies that assess the effectiveness of online versus face-to-face creative thinking courses could provide a nuanced understanding of the strengths and limitations of each approach. Such research would inform educational strategies by identifying the contexts in which one format might be more effective than the other, particularly in a post-pandemic world where hybrid learning models are becoming increasingly prevalent.

The challenges and opportunities presented by the COVID-19 pandemic have catalyzed a transformation in education. This study underscores the potential of online learning to cultivate creative and critical thinkers. The final section will summarize these contributions and reflect on their broader implications for the future of education.

CONCLUSION

This study provides valuable insights into the effectiveness of online education in fostering creative and critical thinking among young learners, particularly in a cross-cultural context. The course described in this paper demonstrated that, with thoughtful design and culturally responsive teaching, online platforms can serve as a powerful medium for enhancing students' problem-solving abilities and encouraging independent, original thinking (Karakose, 2021; Pokhrel & Chhetri, 2021).

The initial challenges faced by the students, such as their hesitation to engage in creative tasks, underscore the importance of creating a supportive and flexible learning environment. The progress observed throughout the sessions suggests that when students are given the freedom to explore ideas without fear of making mistakes, they can develop deeper cognitive skills and a greater willingness to participate actively in their learning process (Karakose, 2021).

Moreover, the success of the course highlights the potential of integrating creative elements into the mathematics curriculum. By blending logical reasoning with creative tasks, students not only enhance their problem-solving skills but also develop a more positive attitude toward STEM fields (Karakose, 2021; Pokhrel & Chhetri, 2021). This interdisciplinary approach aligns with the broader goals of STEAM education, which aims to prepare students for the multifaceted challenges of the modern world.

The findings of this study carry important implications for the future of education, particularly in a post-pandemic world where online learning is expected to remain a significant component of educational systems. Educators and policymakers should leverage the lessons learned from this experience to design future curricula that use online education not merely as a substitute for face-to-face learning but as an opportunity to innovate and improve upon traditional methods (Pokhrel & Chhetri, 2021).

Finally, while this study offers valuable insights, it also opens avenues for further research. Future studies should investigate the long-term impact of such online courses, assess their applicability across

different age groups and cultural contexts, and compare the effectiveness of online and traditional face-to-face instruction in fostering creative thinking (Karakose, 2021).

In conclusion, the challenges posed by the COVID-19 pandemic have catalyzed a transformation in education, creating new opportunities to rethink and reshape how we teach and learn (Karakose, 2021). This study demonstrated that carefully designed online math courses, particularly those that thoughtfully address cultural factors, can foster creative thinking. The success of this course illustrates that, with the right approach, online education can play a pivotal role in developing the creative and critical thinkers of tomorrow.

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Declaration of interest: The author declares no competing interest.

Data availability: Data generated or analyzed during this study are available from the author on request.

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