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Characterizing Creative Teachers and Students

Alexis Michael B. Oledan[1,] ***, Auxencia A. Limjap**[2]

[1]Integrated Developmental School, College of Education, MSU-Iligan Institute of Technology, Iligan City, Philippines
[2]Science Education Department, Bro. Andrew Gonzalez FSC College of Education, De La Salle University, Malate, Manila, Philippines
*****Corresponding author email: alexismichael.oledan@g.msuiit.edu.ph

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Abstract. Creativity is an essential 21st-century skill that students must cultivate across all subjects, including mathematics. While mathematical creativity lacks a universal definition, there is broad consensus among researchers on its importance for students to appreciate the underlying techniques and concepts of mathematics. However, teachers often face challenges in designing activities that effectively promote this creativity. This study investigates the roles of teachers participating in lesson study and students engaging in enhancement classes to explore how creative qualities can be fostered. Employing a single case study approach, the research incorporated open-ended mathematical tasks within research lessons to examine creativity as a personal trait. Data were collected from various sources, including portfolios, video recordings, one-on-one interviews, and session logs, focusing on the planning, implementation, and reflection stages involving both teachers and students. The findings highlight key characteristics of creative teachers and students. For teachers, three primary themes emerged: the quality and effectiveness of teaching strategies, open-mindedness, and flexibility, alongside other divergent thinking skills. For students, the critical themes identified were mental ability and divergent thinking, open-mindedness, and resourcefulness. Overall, the study underscores the importance of fostering these creative qualities in both teachers and students to enhance mathematical creativity and improve the educational experience.

Keywords: Mathematics, Creativity, Creative Teachers, Creative Students, Lesson Study

1. Introduction

There has been extensive research exploring the connection between personal traits and creativity. Researchers like Barron (1969) and Barron & Harrington (1981), as cited by Tang and Gruzka (2017), identified key personal qualities linked to creativity, including intrinsic motivation, broad interests, independence of judgment, and a creative self-concept. The role of intrinsic motivation has been widely recognized, with Amabile (1983) highlighting it as a core component of her componential model of creativity. Furthermore, Gruber (1986) emphasized the importance of dedication in highly creative individuals, while Perkins (1988) noted that challenging tasks can stimulate creativity by drawing on this intrinsic drive.

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While intrinsic motivation is often considered favorable for creativity, Tang and Gruzka (2017) also suggested that extrinsic incentives do not always hinder creative performance. On the contrary, rewards can sometimes enhance certain aspects of creativity, encouraging students to put more effort into tasks and fostering healthy competition among peers.

Creativity has also been conceptualized through frameworks like Guilford's person-centered model, which examines personal, motivational, and temperamental traits as well as the work habits of exceptionally creative individuals (Vogel, 2014). Guilford argued that creativity involves not only generating ideas but also how individuals apply their knowledge and intelligence. Personal qualities such as perseverance, willingness to learn, and the ability to take risks are critical to maintaining high levels of creative performance.

Grainger and Barnes (2006) further expanded on the idea of creativity, proposing that it should be viewed as a dynamic process—a "serious play of ideas and possibilities"—rather than just a final product. In line with this, Daud, Omar, Turiman, and Osman (2012) stressed the importance of critical thinking in fostering creativity. They argued that creative thinking requires an understanding of its foundational processes, which can be developed through both learning and life experiences.

Divergent and convergent thinking are also essential components of creativity, as noted by Nadjafikhah and Yaftian (2013), who drew on Guilford's four elements of divergent thinking: fluency (number of ideas), flexibility (variety of ideas), novelty (uniqueness of ideas), and elaboration (development of ideas).

While the literature provides a robust exploration of creativity, there is relatively limited research on the influence of culture in this area. Culturally-based studies suggest that while creativity in mathematics is valued across different countries, there are varying perceptions and approaches to teaching it. Pitta-Pantazi, Kattou, and Christou (2018) identified traits frequently associated with mathematical creativity, such as open-mindedness, individuality, perseverance, and conciseness. However, Davis (2004) emphasized that possessing these traits does not necessarily equate to being mathematically creative, cited by Pitta-Pantazi, Kattou, and Christou (2018).

This study builds on these foundations to explore the characteristics of creative teachers and students in the context of fostering mathematical creativity. By investigating both intrinsic and extrinsic factors, this research aims to offer insights into how creativity can be nurtured and developed within educational settings.

2. Objectives of the Study

The primary objective of this study is to identify the characteristics of both teachers and students that contribute to fostering mathematical creativity. This study aims to explore the cognitive abilities, personality traits, and biographical experiences that define mathematically creative individuals, providing insights into how these factors influence creative thinking in mathematics education.

3. Methodology

The study employed a one-group case study design grounded in qualitative research methodologies. It focused on the engagement of secondary mathematics teachers in Lesson Study, where they collaboratively designed and implemented four research lessons that featured open-ended mathematical tasks. A narrative approach was utilized to examine students' mathematical creativity through their collaborative efforts and divergent thinking.

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The research involved two groups:

Secondary Mathematics Teachers: Seven teachers from both public and private institutions in Iligan City, Philippines, participated. These teachers had prior experience with Lesson Study and open-ended mathematical tasks and volunteered for the study.

Grade 10 Students: Up to 19 students from a laboratory high school in Iligan City voluntarily participated in an enhancement class where the research lessons were conducted. Participants were coded as TM1 for teacher male, TF for teacher female, SM student male and SF for student female.

Data were collected from multiple sources:

Audiovisual Records: These captured interactions between teachers and students during the planning, implementation, and reflection phases of the Lesson Study.

Semi-Structured Interviews: Conducted with five teachers and seven students, these interviews allowed teachers to discuss the challenges and competencies associated with Lesson Study, while students reflected on their experiences with open-ended tasks and their creative processes.

Students' Session Logs: Collected through Google Forms, these logs captured students' reflections after each research lesson, documenting their feelings, challenges, and experiences.

Data analysis followed a thematic content analysis approach, as described by Carreira and Amaral (2018), which involved coding the data, identifying themes, organizing codes and themes , and interpreting findings. The analysis was inductive, focusing on understanding the experiences of teachers and students without testing a preconceived theory, consistent with the approach taken by Monahan (2021).

4. Results and Discussion

The qualitative data from the one-on-one interviews with the teacher and student participants resulted in three primary themes for creative teacher and student characteristics. There was also a discussion of some other noteworthy traits of a creative individual. A discussion of the creative attributes of a person, teacher, and student from the literature was also discussed, along with proof that teacher and student participation elicited the themes.

4.1 Characteristics of Creative Teachers

This study highlights essential characteristics of creative teachers as perceived by both educators and students, focusing on their roles in fostering mathematical creativity through open-ended tasks. The findings align with Cremin's (2015) emphasis on the importance of teachers understanding their creativity to enhance students' capacities for original thought.

A. Quality and Effectiveness of Teaching Strategy. Creative teachers demonstrate their creativity through well-planned and effective teaching strategies. Interviews with participants revealed that teachers' effectiveness is closely linked to their planning and execution of lessons which were relevant to Lin's (2011) creativity paradigm's "teach creatively" component.

> TM1 emphasized: "Your lesson should be planned... It would require your time. A creative teacher would use their time to plan things."
>
> TF2 noted: "I can say that a person is a creative teacher if his activities are varied and engaging... if an activity is student-centered, he can cultivate the student's creativity."

During teachers' planning sessions, most especially for Creative Teachers' Lesson Study Group, their developed open-ended mathematical tasks promote students'

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realization of the importance of mathematical concepts in real-life settings. Also, the researcher would like to argue from the reflection sessions, the students were engaged during their participation in the enhancement classes. Teacher participants planned students' engagement as they opted to employ the tasks by groups to encourage communication and collaboration. These skills, together with creativity, are essential for an individual to adapt to real-world situations. Thus, a creative teacher ensures that the experiences cultivated are engaging to both the educator and the learner during the lesson proper and make a significant impact in their lives even outside of a school setting (Lawrence, 2016).

Three of the 7 interviewed students also perceived that teachers are creative based on teachers' ability to carry out and develop their lessons. The mentioned arguments by these students imply that their experience with dealing with open-ended mathematical tasks, which were novel to most students, have caused the perception that creative teachers have the characteristic to vary their practices appropriate and enjoyable for their type of students. Since mathematics is arguably a complex subject for secondary students, teachers should live up to the challenge of transforming their lessons to be more creative because the mathematical tasks were enjoyable, appropriate, and meaningful.

This highlights the view that a creative teacher not only designs varied and engaging activities but also ensures they facilitate real-life applications of knowledge.

B. Open-mindedness. Open-mindedness emerged as a critical trait for fostering creativity. Participants recognized the value of being receptive to new ideas and diverse solutions during lessons. With the nature of the multiple solutions from a given open-ended mathematical task, SF1, SF7, SM2, and SM6 argued that creative teachers should be open to different solutions. The researcher would like to argue that this was anticipated already by teacher participants as they were oriented toward the benefits of letting students deal with multiple solution tasks and agreed to incorporate these tasks into their research lessons.

> SM1 reflected: "Part of the teacher's characteristics is to understand the students' ideas and help them improve those ideas... they should respect the ideas of the students."
>
> TM3 argued: "Teachers should be open-minded to new ideas and strategies..."
>
> This openness allows for a richer exchange of ideas, enhancing students' engagement and creative thinking.

Moreover, TF3 responded that creative teachers should be open-minded to accept corrections and suggestions from other teachers on a better way to implement a lesson and make a well-balanced teacher-student interaction where not all ideas come from the teachers. While engaged in lesson study, it was evident that teachers were also exposed to the ideas of other teachers and students. Teachers were exposed to different teaching strategies and shared practices, especially during the planning and reflecting on lesson research implementations.

Moreover, from the reflection sessions, observing students during their break-out sessions exposed not only the researcher but also all teacher participants of students' varied ideas, causing them to reflect on the success and be open for rooms for improvement in implementing the lessons. The mentioned notion of a creative person was also argued by Pitta- Pantazi, Kattou, and Christou (2018) that an individual's open-mindedness is a characteristic of a creative person. Teachers are innately curious, and this trait spurs them to want to learn about what they are interested in genuinely. Such individuals are likely to develop exciting ways in a classroom setting that would enable learners to develop the same genuine desire for knowledge as they do (Cremin, 2015).

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C. Flexibility and Divergent Thinking Skills. Teachers exhibited flexibility in their approach, generating multiple solutions and adapting to various teaching strategies. This flexibility is crucial for guiding students in divergent thinking.

SM1 and SM6 stated: Teachers should think of ideas on how to guide students and trigger them to think divergently.

The ability to navigate different instructional methods not only promotes creativity in students but also showcases teachers' adaptability and innovative thinking. Another idea of teachers being flexible was mentioned in the study of Moore-Russo and Demler (2018) as they cited Lev-Zamir and Leikin (2011) that it is a must for teachers to be flexible not only mathematically but pedagogically as well to be able to teach mathematics in varied ways transforming instructional set-ups. Teachers should also transform how students learn content mathematics and meet the needs of the students. Teacher participants were observed being flexible as each lesson study group chose two different open-ended mathematical tasks to be implemented, which were varied.

D. Passion and Motivation. Finally, passion for teaching was identified as a driving force behind creativity. As TM3 pointed out: "Teachers would not become creative if they do not have the desire and motivation for the things they were doing."

Teachers' dedication to their craft plays a significant role in their ability to develop and implement creative activities, further impacting student engagement and learning outcomes.

The study underscores that fostering creativity in mathematics education relies on teachers' quality of planning, open-mindedness, flexibility, and passion. By embodying these traits, teachers can significantly enhance students' mathematical creativity and problem-solving skills, preparing them for real-world applications and challenges. The results of the study are aligned with the findings of the study of Davis and Rimm (2004) where gifted students defined a good teacher through three major categories: "1) qualities in teachers; 2) excellent teaching; and 3) the unique qualities of the individual student-teacher relationship."

4.2 Characteristics of Creative Students

This research aimed to enhance students' mathematical creativity through open-ended tasks, drawing on Lin's Creativity Framework and highlighting essential 21st-century skills. The findings reveal key characteristics of creative students as perceived by both teachers and peers.

A. Mental Ability and Divergent Thinking Skills. Yaftian (2015) argued that a characteristic of a creative person involves an individual's style of thinking, while Pitta-Pantazi, Kattou, and Christou (2018) mentioned different cognitive abilities. Arguably, creativity could also be considered mental ability and divergent thinking skills. Most of the interviewed student participants, 5 out of seven, considered creative students concerning their thinking abilities. It was worth noting that a creative student's thinking abilities were drawn out from student participants after they participated in the enhancement class. Moreover, two out of five teachers also mentioned some traits of creativity among students concerning thinking abilities.

Students SF10, SF4, and teacher TF2 mentioned that thinking outside the box is a trait of a creative student. This trait was evident to students in coming up with their outputs from the open-ended mathematical tasks. During the task about street lamps, TM2 shared that a student thought of two-way lanes where others were just focused on one-way lanes. Creative students demonstrate strong mental abilities and divergent thinking skills. Five out of seven student participants recognized that creative thinking, cultivated through engagement in open-ended tasks, is vital for originality.

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SM1 described: “Even if the equation is simple, students can analyze what they can do to make the equation unique... The ability to make a simple situation become complex.”

SF1 added: “I feel that a student is creative if he is willing to answer open-ended activities and prefers that kind of activities.”

From teachers point of view, TM3 mentioned as well the previously discussed creative characteristic of an adult, which is being curious, that is, “the capacity to be puzzled; actively experimenting with ideas and the pleasure in seeking and discovering ideas (Guilford, 1973).” This implies that a characteristic of a creative adult may not be exclusive to professionals, but students, such as Grade 10 students, should also elicit such traits from TM3’s perspective. In the checklist of highly creative students identified by Guilford, he mentioned that “students should experiment with whatever is at hand, the student asks many questions and prefers talking about ideas and problems,” to mention a few. The researcher and teacher participants reflected that some student participants were able to experience and elicited these mentioned characteristics of

creative students as TF2 and TF3 argued that they could collaborate and share their ideas.

These insights suggest that creative students excel in transforming simple concepts into more complex ideas, driven by their curiosity and engagement.

B. Open-mindedness. Open-mindedness was frequently cited as a critical trait of creative students. Participants recognized that accepting diverse ideas enhances collaboration and creative output. On the other hand, SM6 and SF7 mentioned open-mindedness as essential in accepting critiques and admitting mistakes.

SM2 stated: “You accept ideas of others because it will help during group activities...”

TM3 emphasized: “If you are a creative student, you are also willing to learn from your co-students...”

The arguments of TM3 imply that willingness to listen and learn from others, even from co-students, is a creative trait. Open-mindedness means acknowledging that they also have other ideas that a student could utilize to develop a practical course of action in doing the tasks. Through review of literature, the researcher believes that being open-minded promotes the ability and skill to collaborate. TF3 mentioned that being able to collaborate is a creative characteristic of a student. However, during group discussion, it was observed that some students do the task individually at first, which could be considered normal in most group activities. Through proper collaboration guidance, students learned to compromise and accept suggestions.

These comments highlight that open-mindedness not only fosters individual creativity but also enriches the collaborative learning environment.

C. Resourcefulness. Students demonstrated resourcefulness in their approach to tasks, leveraging technology and online resources to develop creative solutions. From teachers' reflection sessions, done days after implementation of each research lesson and invited external observers, the teachers also consider students creative if they are resourceful. In generating ideas, teachers agreed that students were very resourceful. They searched the web for a more realistic output, using different online and offline apps. Also, because of the online environment of the enhancement class, the use of technology was welcomed by teachers and did away with the traditional idea that students should do them manually and on their own. Some of their outputs were also patterned and revised from provided examples. It was also discussed that students share personal ideas and experiences to produce an output within their group. In conclusion, students were able to develop many varied and original ideas.

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Being resourceful was also mentioned in students' responses on a google form as their reflection activity. SF12 shared that she was used to just solving algebraically and was able to explore the applications and existence of parabolas with its practical use through searching the web.

SF13 reflected: “Luckily, as students that are openly exposed to technology... we were able to find ways to work on the activity with platforms such as Google Docs, Canva, and Desmos.”

SF2 shared: “I was able to get pieces of information that I can share within the group.”

Doing open-ended mathematical tasks that incorporate actual life applications could have been time-consuming for students as they need to plan thoroughly to develop good responses. However, through this kind of activity, other skills and knowledge like utilizing graphing apps without being instructed imply that students thought of solutions and ways to do the task at hand. For task 4, teachers observed students searching the web to fully understand how a rural bank works, including existing bank savings schemes and basic terms about investments. Some students thoroughly discuss the details of their schemes, from the type of client and accurate interest rates to their drafted formula.

This resourcefulness indicates that creative students are adept at utilizing available tools and information to enhance their learning experiences.

D. Other Indicators of Creativity. Personal experiences and the ability to reflect on them emerged as indicators of creativity among students. Teachers noted that real-life applications in tasks allowed students to connect their learning to practical situations.

SM1 articulated: “The students should have plenty of knowledge... as long as they can understand more concepts in life that they can use in different ways.”

SM2 pointed out: “Patience jud siya, Sir... you have to be patient with yourself then trust yourself.”

These insights underscore the importance of life experiences and perseverance in fostering creativity, aligning with Guilford's criteria for creative individuals.

The study illustrates that enhancing students' mathematical creativity requires cultivating mental abilities, open-mindedness, resourcefulness, and the ability to reflect on personal experiences. By fostering these characteristics, educational institutions can better prepare students for the complexities of the 21st century.

4.3 Students’ Perception of Fostered Creative Characteristics

Students generally reported that the research lessons improved their creativity by allowing them to showcase their ideas, which were often kept to themselves in more traditional classroom settings. The open-ended tasks helped students develop critical thinking skills, apply creativity to real-life problems, and explore multiple solutions to a single problem. SM1, for instance, reflected that participating in the enhancement class made it easier to stimulate creative thinking. He emphasized that the tasks exposed him to problems with various possible solutions, enabling his creativity not only during the class but in broader applications.

Students also highlighted the importance of collaboration in fostering creativity. SF4, SM2, SM1, and SF7 shared that working with peers during the enhancement class improved their decision-making and problem-solving abilities. They believed that these activities were more beneficial compared to their regular math classes, where the focus was often on procedural methods rather than creative exploration. Many students felt encouraged to "think outside the box" and appreciated the collaborative atmosphere, which helped them brainstorm ideas and explore new perspectives.

The sentiment among students was optimistic. They felt that the enhancement class provided a platform to exercise creativity through teamwork, brainstorming, and problem-

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solving. SF1 concluded that the research lessons fostered not only her creativity but that of her peers as well.

4.4 Teachers' Challenges and Reflections on Creativity Development

Despite the successes, teachers acknowledged the challenges of fostering creativity through open-ended tasks. TM1 reflected on the difficulty of determining individual student improvement, noting that it was easier to observe creativity in group interactions rather than in individual responses. He also mentioned the challenge of comparing creativity across different tasks, as each activity required varied levels of thinking.

Teachers further reflected on the components of creative ideas, with some suggesting that limiting the number of initial responses (fluency) might help students focus on producing more varied and original outputs. There was also discussion about incorporating inter-subject open-ended tasks, particularly those inspired by real-life situations, to further enhance creativity.

When asked if their participation in the study had made them more creative as teachers, most agreed. TM3 expressed that he had become a quick thinker, often sharing new ideas with his colleagues. TF3, who initially found student-centered activities challenging, noted that her understanding of how to handle such activities became clearer as she gained exposure to strategies for enhancing creativity. TF2 also recognized her own creative growth, stating that participating in the research had helped her identify areas where she could improve.

5. Conclusion

This study has illuminated the key characteristics of creative teachers and students essential for fostering mathematical creativity. Through qualitative data from interviews and relevant literature, several important findings have emerged. Creative teachers are distinguished by their ability to design engaging, varied activities that prioritize student-centered learning. They emphasize effective lesson planning and exhibit openness to new ideas and strategies. Additionally, creative teachers demonstrate flexibility and divergent thinking skills, embracing innovative approaches that transcend traditional teaching methods. In contrast, creative students showcase critical thinking abilities, curiosity, and the capacity to generate multiple solutions to problems. They are open to diverse perspectives, collaborate effectively with peers, and leverage various tools and platforms to enhance their learning experiences. Moreover, they draw on personal experiences to deepen their understanding and application of concepts, exhibiting diligence, patience, and perseverance in their academic pursuits.

These findings highlight the importance of cultivating a supportive learning environment that nurtures creativity among both teachers and students. By fostering these creative characteristics, educators can effectively promote mathematical creativity and empower students to excel academically. Moving forward, it is vital for educational institutions to prioritize the development of creative teaching methodologies and to cultivate a culture of innovation and collaboration within the classroom. Through ongoing efforts to nurture creativity, we can equip students with the skills and mindset necessary to thrive in an increasingly complex and dynamic world.

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