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Fostering Creative Mathematical Thinking with a Flipped Classroom Approach

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ABSTRACT

Mathematics education in this digital era requires innovative and creative learning models to improve the quality and creativity of students. The flipped classroom model has become one of the alternatives that can be implemented in mathematics education in the 21st century. This study aims to review several articles examining the flipped classroom model on elementary school student's mathematical creative thinking skills. The research method used is a literature review which begins with identifying research problems, searching for literature, evaluating data, and analyzing it. The literature review results show that the flipped classroom model has several advantages over the conventional learning model, such as increasing student engagement in the learning process and providing opportunities for students to develop creative thinking skills. In addition, using the flipped classroom model also positively influences students' abilities to solve measurement-related problems. Flipped classroom model provides a learning experience that is fluency, flexibility, originality, and elaboration. This article offers several recommendations for the development of the flipped classroom model in the future, such as the use of more varied learning media and the development of more interactive teaching materials. Therefore, this article can be a reference for educators and researchers interested in developing effective learning models to enhance students' mathematical creative thinking skills.

Keywords: mathematical, Creative Thinking Skills, Flipped Classroom

ABSTRAK

Pembelajaran matematika di era digital ini membutuhkan model pembelajaran yang inovatif dan kreatif agar dapat meningkatkan kualitas dan kreativitas siswa. Model pembelajaran flipped classroom menjadi salah satu alternatif yang dapat diimplementasikan dalam pembelajaran matematika pada abad 21. Penelitian ini bertujuan untuk mereview beberapa artikel yang meneliti model pembelajaran flipped classroom terhadap keterampilan berpikir kreatif matematis siswa Sekolah Dasar. penelitian yang digunakan yaitu kajian literatur yang dimulai dengan mencari masalah penelitian, mencari literatur, mengevaluasi data, dan menganalisisnya. Hasil studi literatur menunjukkan bahwa model pembelajaran flipped classroom memberikan beberapa kelebihan dibandingkan dengan model pembelajaran konvensional, seperti meningkatkan keterlibatan siswa dalam proses belajar dan memberikan kesempatan bagi siswa untuk mengembangkan keterampilan berpikir kreatif. Selain itu, penggunaan model pembelajaran flipped classroom juga memberikan pengaruh positif terhadap kemampuan siswa dalam memecahkan permasalahan yang berkaitan dengan pengukuran. Model flipped classroom menyediakan pengalaman belajar berpikir kreatif lancar, fleksibel, orisinil, dan rinci. Dalam artikel ini, diberikan beberapa rekomendasi bagi pengembangan model pembelajaran flipped classroom di masa depan, seperti penggunaan media pembelajaran yang lebih variatif dan pengembangan bahan ajar yang lebih interaktif. Dengan demikian, artikel ini dapat menjadi referensi bagi para pengajar dan peneliti yang tertarik dalam pengembangan model pembelajaran yang efektif dalam meningkatkan keterampilan berpikir kreatif matematis siswa.

Kata Kunci: matematika, keterampilan berpikir kreatif, flipped classsroom

INTRODUCTION

A practical approach to teaching mathematics in primary schools in the 21st century should be tailored to meet the unique needs of students and the changing technologies. Innovative learning models that prioritize the development of creative thinking skills, such as logical thinking, problem-solving, and decision-making, should be emphasized (NCTM, 2017). The National Council of Teachers of Mathematics (NCTM) recognizes the importance of innovative learning models that foster the development of creative thinking skills. These skills, including logical thinking, problem-solving, and decision-making, are critical for students to become effective problem-solvers and to apply mathematical concepts in real-world contexts.

Creativity plays a crucial role in education in fostering innovative thinking and problem-solving skills. It encourages students to approach challenges with unique perspectives and generate novel solutions. As educators strive to cultivate creative thinking among their students, the flipped classroom approach has gained considerable attention. This approach reverses the traditional instructional model by delivering content outside the classroom through pre-recorded videos, readings, or online resources while using class time for collaborative activities, discussions, and problem-solving and mathematical literacy. Mathematical literacy prepares future generations to deal with changing world challenges (Alghadari et al., 2022).

In mathematics education, one area that greatly benefits from creative thinking is measurement. Measurement concepts provide a foundation for understanding and quantifying the physical world, and creative mathematical thinking can enhance students' engagement and comprehension of measurement content. However, despite the potential benefits of the flipped classroom approach and creative thinking in teaching measurement, a gap analysis is necessary to identify areas where current educational practices may fail to promote creativity effectively. The gap analysis related to creativity in the context of a flipped classroom approach on measurement content refers to examining the current state of educational practices regarding fostering creative mathematical thinking. It involves identifying gaps and areas of improvement in instructional strategies, assessment methods, and curriculum design that hinder the development of students' creative thinking skills about measurement concepts. By conducting a thorough gap analysis, educators and researchers can gain valuable insights into the challenges and opportunities of implementing a flipped classroom approach for teaching measurement content creatively.

This article explores the gap analysis related to creativity in the context of a flipped-classroom approach to measurement content. We will delve into the factors contributing to the existing gaps, such as curriculum constraints, pedagogical practices, and assessment approaches. By identifying these gaps, we can propose strategies and recommendations for bridging them and optimizing the use of the flipped classroom approach to enhance creative mathematical thinking in the context of measurement education. This article aims to comprehensively understand the gap analysis related to creativity in the context of a flipped-classroom approach to measurement content. By addressing these gaps, we can promote more effective and engaging learning experiences for students, fostering their creative thinking abilities and enabling them to apply measurement concepts creatively in real-world situations.

Developing mathematical creative thinking skills is crucial for the character and quality of human resources in Indonesia. Creative thinking is essential in achieving a profound conceptual understanding of mathematics. However, developing creative thinking skills is challenging, and teachers cannot directly teach it. Instead, teachers can create a conducive learning environment that encourages creativity. This can be achieved using technology tools such as graphic design software, interactive teaching materials, and learning videos to stimulate creative ideas (Al-Zahrani, 2015). The lack of creative thinking ability in students can have a significant impact on their overall learning outcomes. To address this issue, innovative and creative learning models are required. The flipped classroom learning model is one such model that can be implemented in the digital era to improve the quality and creativity of students. This model involves using technology to enhance the quality of learning and assigning students digital resources, such as e-books or videos, to learn before classroom activities. The traditional roles of teachers and students are reversed in this model, where students take an active role in their learning process (Akçayır & Akçayır, 2018).

Mathematics learning often involves measurement materials requiring high creative thinking skills. For instance, students must apply various problem-solving strategies to calculate the area of irregular shapes. The flipped classroom learning model can effectively improve students' mathematical creative thinking skills by providing a learning environment that combines technology, social interaction, and relevant challenges. This model facilitates a collaborative learning experience where students acquire information from the teacher and collaborate with their peers to solve complex problems. The flipped classroom is characterized by reversing the traditional roles of homework and classroom activities, with students actively learning the material at home through digital media and then participating in classroom activities to reinforce their learning.

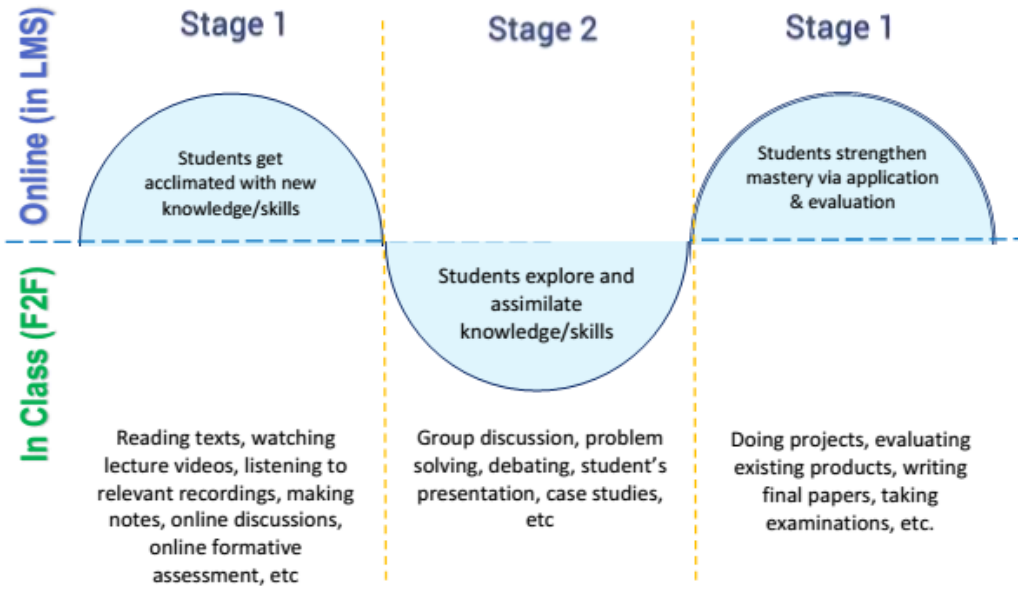

Figure 1. Stages and Modes of Learning in a Flipped Classroom

The figure above illustrates how the flipped classroom model provides students with initial exposure to course content outside of traditional classroom settings through various forms of media, including reading materials, videos, and audio recordings. Students then engage in face-to-face

sessions where they can clarify complex concepts and deepen their understanding through collaborative activities such as class/group discussions, case studies, debates, and problem-solving. Finally, students apply what they have learned by creating products or projects, culminating in a final test or exam. This model provides a comprehensive and interactive learning experience that promotes student engagement and a deeper understanding of the subject matter. Homework and assignments encourage students to review and practice what has been taught in class. For students with access to sufficient learning resources, this approach can be highly effective in motivating and challenging them to re-learn the material and explore it further. Based on the above description, it can be concluded that the flipped classroom model involves moving traditional in-class activities to be completed at home beforehand while using class time for reinforcing complex concepts and engaging in group discussions, case studies, debates, problem-solving, and student presentations (Sutisna et al., 2019). Students are expected to actively seek out and utilize relevant learning resources through information technology throughout the learning process (Setyawan & Rohmah, 2021).

The gap analysis related to the flipped classroom approach includes (a) Effective Learning Planning: While the flipped classroom model offers flexibility and diverse learning resources, there are still challenges in planning effective learning. Teachers must ensure that the content delivered outside the classroom is genuinely relevant and provides a strong foundation for understanding the concepts. Additionally, developing appropriate learning resources, such as videos or reading materials, requires extra time and effort, (b) Accessibility of Learning Resources: The flipped classroom model relies on students accessing learning resources outside the classroom, primarily through technology. However, not all students have equal access to technology devices and stable internet connections. This can be a barrier for students who cannot access the necessary learning resources, thus reducing the effectiveness of the flipped classroom model in reaching all students, (c) Monitoring and Individual Feedback: In the flipped classroom model, students often learn the material independently outside the classroom. Therefore, teachers need to monitor students' progress and understanding individually effectively. Providing relevant and specific feedback on students' knowledge is critical to helping them overcome difficulties or misconceptions that may arise, (d) Active Role of Students: In the flipped classroom model, students are expected to take the initiative in seeking relevant learning resources and preparing themselves before class. However, not all students are accustomed to self-directed learning and developing practical skills. Therefore, guidance and mentoring from teachers are needed to develop these skills and ensure that all students can maximize the benefits of the flipped classroom model.

This gap analysis identifies several aspects that need attention and improvement in implementing the flipped classroom model. These include effective learning planning, accessibility of learning resources, monitoring and individual feedback, and mentoring students' learning skills. This research aims to investigate the flipped classroom learning model in mathematical creative thinking skills. The researchers aim to gather information from a variety of sources to gain a better understanding of the topic. The authors will review and analyze existing research on the subject

through a literature study, synthesizing this knowledge to provide a comprehensive and in-depth analysis. The findings of this research may serve as a foundation for further investigation in the field.

METHOD

This research was conducted using a systematic literature review method to review relevant and recent literature in a specific field, to restructure and synthesize previously available information through stages of problem formulation, theoretically based, data collection, analysis, interpretation, and conclusion (Sugiyono, 2018). The steps in the research can be seen in Figure 2.

Figure 2. Stages in This Research

The problem formulation was conducted by formulating the research question on how to describe the role of flipped classroom learning model in teaching measurement with mathematical creative thinking skills. A literature search was performed by collecting primary reference sources such as journals, research reports, undergraduate and graduate theses, dissertations, and secondary reference sources such as books and internet sources. Data evaluation was done to identify relevant data to the research problem. Data analysis was performed by conducting a literature search on several online databases, such as Google Scholar and ERIC, using the keywords "flipped classroom", "mathematics education", and "creative thinking". The data analysis was conducted using a qualitative descriptive approach involving systematic and comprehensive data processing and interpretation.

In conducting a literature review, the common data analysis techniques include a description of each aspect as outlined in the mentioned reference (a) Problem Formulation; this stage involves identifying and defining the research problem or question the study aims to address. It includes clarifying the objectives, scope, and significance of the research (b) Theoretical Basis, theoretical basis refers to the theoretical framework or conceptual foundation upon which the research is built. It involves reviewing relevant theories, models, or concepts that provide a basis for understanding and explaining the phenomena under investigation, (c) Data Collection, data collection involves gathering the necessary information or data to answer the research question or test the hypotheses. It includes selecting appropriate data collection methods, such as surveys, interviews, observations, or document analysis, and designing data collection instruments, (d) Analysis and Interpretation, in this stage, the collected data is analyzed using suitable techniques and tools. The analysis process may involve organizing, coding, categorizing, and summarizing the data. Interpretation refers to making sense of the analyzed data and drawing meaningful conclusions, (e) Conclusion, the decision

is the final part of the research process. It involves summarizing the findings, addressing the research objectives, and answering the research question. The conclusion may also include implications, recommendations, and suggestions for further research.

RESULT AND DISCUSSION

The study reviewed existing literature on using flipped classroom models in teaching mathematics, particularly measuring and developing students' mathematical creative thinking skills. Based on the literature review, the study found evidence suggesting that implementing the flipped classroom approach can improve students' mathematical abilities and creative thinking skills.

Table 1. Comparison of Findings on the Use of Flipped Classroom in Fostering Creative Mathematical Thinking.

Literature	Main Findings
Tabieh & Hamzeh (2022): "The Influence of the Flipped Classroom on Students' Creative Mathematical Thinking Skills"	The flipped classroom can enhance students' creative mathematical thinking skills by developing fluency, flexibility, originality, and elaboration. The use of flipped classrooms can improve the problem-solving abilities and creative mathematical thinking skills of students.
Rucker et al. (2017): "Enhancing Problem-Solving and Creative Thinking Skills through Flipped Classroom Instruction in Mathematics."	The flipped classroom model can improve students' math abilities and learning interests. The flipped classroom positively impacts students' interest and motivation in mathematics learning.
Peterson (2016): "Improving Math Abilities through Flipped Classroom Approach: A Study on Middle School Students"	The influence of flipped classrooms on students' mathematical abilities and creative thinking skills is not always consistent. The use of flipped classrooms can improve students' creative mathematical thinking skills.
Brewer & Movahedazarhouligh (2018): " Successful Stories and Conflicts: A Literature Review on the Effectiveness of Flipped Learning in Higher Education "	The flipped classroom can enhance students' problem-solving and creative mathematical thinking skills. Flipped classroom provides adequate learning time, increases student engagement, and improves teacher-student interaction.
Langgi (2022): The Influence of Problem-Based Learning Model with Flipped Classroom on Creative Thinking Abilities	There is a significant influence in improving students' creative thinking abilities using the PBL model with the Flipped Classroom approach. Students engaged in learning using this model showed better improvement in creative thinking abilities compared to those involved in conventional learning
Lestari et al. (2020): The effect of the flipped classroom approach and self-efficacy on a guided inquiry on students' creative thinking skills	The results showed that guided inquiry learning with the flipped classroom approach and high self-efficacy categories had high creative thinking abilities. Still, there is no interaction between learning models with self-efficacy towards creative thinking abilities on the reaction rate material because learning models and self-efficacy affect the results of students' creative thinking skills.

Mathematical creative thinking is an essential skill for students in solving mathematical problems. In the elementary school lesson on measuring the area of squares and rectangles, the development of indicators for creative mathematical thinking skills is crucial. One learning model that can be used to achieve this is the flipped classroom model. In the flipped classroom model, students acquire learning materials at home through video lessons or readings, while classroom time is devoted to working on math problems or tasks. Teachers can encourage students to think creatively in math by providing challenging math problems and asking students to find different solutions. This can stimulate skills in creative thinking, analysis, and originality.

In learning the measurement subject, several learning experiences can support the development of students' creative mathematical thinking. Firstly, learning experiences can help students develop their fluency skills through continuous practice in understanding the concepts and calculating the area of squares and rectangles. Teachers can provide various exercise problems that require calculating the size of different shaped squares and rectangles. Additionally, using interactive learning media, such as math games, can also help students practice their fluency skills.

Secondly, learning experiences can help students develop their flexible skills by giving them tasks requiring creative thinking. Students can be given tasks to find various ways to calculate the area of squares and rectangles and explore the relationship between the two. This can help students practice their flexible skills in creative mathematical thinking. Thirdly, learning experiences can help students develop their original skills by providing challenging mathematical problems and asking students to find different solutions. Unusual or complex mathematical problems can help students build their actual skills in creative mathematical thinking. Fourthly, learning experiences that can help students develop their elaboration skills are by asking them to explain their calculation steps in detail. Teachers can provide effective feedback on student's work and help students improve their understanding of the material. This can help students improve their elaboration skills in creative mathematical thinking (Kyriakides et al., 2019).

This aligns with research conducted by Rucker et al. (2017), which shows that flipped classrooms can improve students' problem-solving abilities and creative mathematical thinking skills. The study found that students who participated in flipped classroom learning had better problem-solving abilities and higher mathematical creative thinking skills than those who participated in conventional education. From the results of research in the United States and practices in several schools in Indonesia, it is known that flipped classroom provides positive outcomes and better learning quality than traditional methods. Students who use this method show high levels of learning motivation, increased creativity, greater responsibility, and are more active in participating in classroom learning. In addition, their academic performance is also better than students who use traditional learning methods. Teachers also feel they have more time to interact with students (Kemdikbud, 2020).

In addition, Peterson (2016) research also shows that flipped classrooms can improve students' math abilities. The study found that the average posttest score of students who participated in flipped classroom learning reached 85.7. In contrast, the average posttest score of students who participated in conventional education only reached 75.4. Furthermore, research conducted by Brewer &

Movahedazarhouligh (2018) also shows that flipped classrooms can positively impact mathematics learning. Their study found that students who participated in flipped classroom learning had higher levels of interest and motivation in mathematics learning than students who participated in conventional education.

With this model, our goal of equipping students with critical thinking, collaboration, communication skills, and creative/innovative thinking abilities can be achieved effectively. The teacher does not dominate the class time. Teacher-student interaction becomes better and more enjoyable. However, research by Tabieh & Hamzeh (2022) shows that the influence of flipped classrooms on students' mathematical abilities and creative thinking skills is not always consistent. This is due to the variation in the use of flipped classrooms in various learning contexts, such as educational levels, mathematics subjects, and the quality of flipped classroom implementation. In this regard, we also recommend that further research pay attention to these factors and conduct more detailed analyses of the variables that influence the success of flipped classrooms in improving students' mathematical abilities and creative mathematical thinking abilities. Furthermore, the research conducted by Peterson (2016) on 6th-grade students in an elementary school in South Korea also showed similar results. They found that the flipped classroom model can improve students' creative thinking ability, especially in divergent and convergent thinking.

In addition, several studies in Indonesia examine the use of the flipped classroom model in improving students' mathematical creative thinking skills. In their research, Ramadhani & Evans (2022) found that flipped classrooms can improve students' mathematical creative thinking skills. This study also showed that students felt more active and engaged in learning, providing a more enjoyable and practical learning experience. Furthermore, the study conducted by Cevikbas & Kaiser (2023) also showed results consistent with the previous study. Their research found that using flipped classrooms can improve students' problem-solving and mathematical creative thinking skills.

There are many benefits to implementing the flipped classroom model. One significant benefit is rich learning time. In the flipped classroom, students can maximize their learning time in class. They can interact, discuss, and develop lesson materials in depth. This helps increase student engagement in learning and provides real-life experiences that can shape their ability to learn independently. In addition, the effectiveness of the teaching and learning process also improves, as students can learn the lesson content at their own pace and in a way that suits their learning style. Learning can be done more interactively and practically, such as creating presentations and solving problems. In this regard, the flipped classroom model provides a solution for developing student skills effectively and efficiently (Indrajit & Patandean, 2020).

In addition, implementing the flipped classroom model is also considered an innovative learning approach that can renew the existing education system. This is because this learning model presents unique and new characteristics in learning, such as collaboration between students and parents in learning at home. Moreover, the relationship between teachers and students improves because teachers have more time to work with each student individually and provide more personalized feedback. The flipped classroom model also helps improve the interaction between teachers and students in learning so that students can quickly master the subject matter and get more meaningful

homework. Overall, the flexibility and motivation of students in learning also increase with the implementation of the flipped classroom model. However, literature studies also show that the success of flipped classrooms in producing students' creative mathematical thinking skills depends on certain factors, such as the quality of learning videos, technological support, and the teacher's ability to conduct practical class discussions. In addition to improving the success of the flipped classroom model, several factors need to be considered: preparing learning materials, quality of learning videos, the interaction between students and teachers, and practical learning evaluation (Turan & Akdag-Cimen, 2020).

The flipped classroom is an excellent technique for an absent teacher, meaning that if the teacher cannot attend the meeting, he can record the learning videos for the students to measure that the learning activity runs well and flipped classroom's advantages are increasing students' learning performance such as satisfaction, engagement, and motivation the flipped classroom allows for natural differentiation (Murillo-Zamorano et al., 2019) The interaction between students and teachers also plays a crucial role in the success of the flipped classroom model. According to Baten et al. (2017), good teacher-student interaction can help students better understand learning materials and encourage their engagement in the learning process. Lastly, practical learning evaluation is also necessary to assess students' understanding and provide helpful feedback to improve the quality of learning (Jensen et al., 2015).

The flipped classroom learning model generally allows students to be more active in the learning process, thereby improving their creative thinking skills. The opinion supports this expressed (Akçayır & Akçayır, 2018), that the flipped classroom learning model allows students to participate more in challenging learning activities, encouraging them to think more creatively and solve problems. Overall, the success of the flipped classroom learning model depends on many factors, including the preparation of materials, the quality of learning videos, the interaction between students and teachers, and practical learning evaluation. By considering these factors, teachers can maximize the success of the flipped classroom learning model in improving the quality of student learning.

Flipped Classroom was developed to provide students with a broader opportunity to explore and gather information before the class meeting so that in the class meeting, students can focus on more creative and innovative activities such as problem-solving, teamwork, and project presentations. This model is expected to improve students' creative thinking skills because they can learn more actively and independently. Based on several expert opinions, it can be concluded that the steps of the flipped classroom strategy are for the teacher to provide teaching materials that will be used for self-learning by students at home before the next meeting. Therefore, teachers should consider these factors in designing effective flipped classroom learning that can improve students' mathematical and creative thinking skills. Flipped classroom as a stimulus to encourage teacher creativity. This is because teachers will be challenged to create valuable and exciting content. Thus, teachers will deploy all their imagination and creativity to do so.

CONCLUSION

Based on the review of several studies on the use of the flipped classroom model of learning, it is evident that students' average mathematics performance significantly improves after following the flipped classroom model of education. Furthermore, this model also effectively enhances student motivation and engagement in mathematics learning. In the flipped classroom, students can learn the material independently before entering the classroom, so they can focus more on applying mathematical concepts in discussions and tasks that require creative thinking skills. The flipped classroom can positively impact students' mathematical and creative thinking skills. The impact of the flipped classroom on students' mathematical ability and creative thinking skills is not always consistent, as variations influence the use of the flipped classroom in different learning contexts.

Teachers need to ensure that the appropriate and consistent use of the flipped classroom model is employed in providing a learning experience to students. Students can obtain course materials outside the classroom by utilizing technology such as instructional videos and reading materials. Classroom time can be used for interaction with teachers and classmates in solving mathematical problems and developing indicators of mathematical creative thinking skills fluently, flexibly, initially, and in detail in the measurement material in Elementary School can be achieved through the implementation of the Flipped Classroom learning model and appropriate learning experiences. Effective implementation of the Flipped Classroom learning model requires thorough preparation, adequate technological support, and commitment from teachers and students in the learning process.

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