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Investigating the Potential of Flipped Classroom in Mathematics Education

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***Abstract*:** *The flipped classroom is an instructional approach and a type of blended learning that includes face-to-face and online components. It uses instructional content like videos, podcasts, or other outside classes and expands that knowledge through activities in class. This study aims to investigate the potential of flipped classrooms in mathematics education. This study used scoping review method. This method used ten articles of quasi-experiment or mix-method analysis. The results showed that flipped classrooms could improve mathematics achievement, critical thinking, creative thinking, computational thinking, learning motivation, and self-regulated learning.*

Keywords: *Potential, Flipped Classroom, Mathematics Education*

1. Introduction

Nowadays, technology is highly needed in various fields. Moreover, the pandemic COVID-19 impacted that activities can be replaced by technology. Especially in education, the learning process should be utilized as learning media or facilitating online learning. For example, in pandemic COVID-19, schools are temporarily closed so that online learning is implemented. It indicated that technology influenced education.

The evolution of technology is presented to facilitate the variety of learning resources. Students can learn everything outside of the classroom anytime and everywhere. Media using network technology and computer were implemented to the types of learning situations, including synchronous and asynchronous network learning free time, location, and schedule [1]. For example, the study by reading e-books, watching videos, playing educational games, etc.

Digital learning is integrating the learning process and technology. Digital learning is one of the characteristics of twenty-first-century learning goals [2]. It contributes to improve student achievement and motivation[3]. Digital learning presented better positive effects on students' learning motivation and learning outcomes[4].

One of the learning models using digital technology is flipped classroom. Flipped classroom is learning strategy that consist of outside and inside classroom, online individual instruction outside the classroom and interactive group learning activities inside the class [5]. Flipped classroom can be defined as an active learning, student-centered approach that was used to improve the quality of period in the class [6]. For educational activities, it provided highly beneficial [7]. The general principle of flipped classroom was creating collaborative spaces, creating individual space, emphasizing student centeredness learning, emphasizing learning not teaching [8].

Flipped classroom was implemented in various subject such as mathematic, physic, chemistry, language, medical, etc. Theoretically, this model is feasible, however several previous studies suggested that there is no significant improvement in learning outcome or motivation [9][10]. It indicated that implementing this model was still ambiguous. Therefore, it is necessary to review the potential of flipped classroom in mathematics.

The purpose of this study is to see the potential of Flipped Classroom in the world of mathematics education by analyzing the results of research on Flipped Classroom using the quasi-experiment or mix method.

2. Method

The method of this study is scoping review. Scoping review is used to assess a potential and scope of research to identify tendency of research evidence [11]. According Arksey and O'Malley, there are five stage of scoping review including 1) identifying the research question, 2) identifying relevant studies, 3) study selection, 4) charting data, 5) arranging, summarizing, and reporting the result [12]. Data was collected through search on Google Scholar and ERIC using the keyword "flipped classroom and mathematic". 15 thousand articles are found from the search result using ERIC and 71 thousand articles found from the search result using Google Scholar which were reduced to 10 articles. The following is the criteria for selecting data.

- Time period: the last 7 years (2016-2022)
- Study focus: mathematics education
- Research method: quasi-experiment, mix-method
- Sample: student and undergraduate student

3. Result and Discussion

The articles were reviewed and summarized. A detailed summary of those variables that are concluded from the included studies are illustrated in table I and table II.

TABLE I: Studies Included into Scoping Review

Researcher	Zaher Atwa et al	Naufal Ishartono	Ali M. Al-Zoubi and Laiali M. Suleiman	Xuemin Gao and Khe Foon Hew	Xuefeng Wei et al
Year	2022	2022	2021	2021	2020
Title	"Flipped Classroom Effects on Grade 9 Students' Critical Thinking Skills, Psychological Stress, and Academic Achievement"[13]	"Integrating GeoGebra into the flipped learning approach to improve students' self-regulated learning during the covid-19 pandemic"[14]	"Flipped Classroom Strategy Based on Critical Thinking Skills: Helping Fresh Female Students Acquiring Derivative Concept"[15]	"Toward a 5E-Based Flipped Classroom Model for Teaching Computational Thinking in Elementary School: Effects on Student Computational Thinking and Problem-Solving Performance"[16]	"Effect of the flipped classroom on the mathematics performance of middle school students" [17]
Subject	16 teachers and 385 students	60 undergraduate students	54 undergraduate students	125 students	88 students
Country	Palestine	Indonesia	Jordan	Hong Kong	China
Method	Quasi-experimental method	Experimental method	Mix-Method	Experimental method	Experimental Method
Instrument	Tests and questionnaire	Questionnaire	Tests and interview	Tests and interview	Test and Interview
Dependent Variable	Critical Thinking Skills, Psychological Stress, and Academic Achievement	Self-Regulated Learning	Critical Thinking Skills	Computational Thinking skills	Mathematics Performance

Result	"The flipped classroom implementation results in statistically significant difference at the level of significance ($\alpha<0.05$) between controlled and experimental groups in favor of the latter one in critical thinking skills, Math achievement and psychological stress."[13]	"The analysis results revealed that GeoGebra-integrated Flipped Learning is more effective in increasing students' self-regulated learning level in online mathematics learning than the other two approaches."[14]	"The analysis of the obtained data showed that teaching Calculus using Flipped Classroom Strategy that based on Critical Thinking Skills is better than the traditional teaching methodology in the acquisition derivative concept."[15]	"The results showed that the 5E-based FCM significantly improved student understanding of CT concepts and computational problem-solving abilities. The results also revealed positive student perception toward the FCM."[16]	"The results show that the proposed flipped classroom approach significantly improves the students' mathematical learning performance."[17]

TABLE II: Studies Included into Scoping Review

Researcher	Chung Kwan Lo and Khe Foon Hew	A R Sya'roni et al	Cheng-Yu Hung et al	William J. Heuett	Kaushal Kumar Bhagat et al
Year	2020	2019	2018	2017	2016
Title	"A comparison of flipped learning with gamification, traditional learning, and online independent study: the effects on students' mathematics achievement and cognitive engagement"[18]	"Students' creative thinking skill in the flipped classroom blended learning of mathematics based on lesson study for learning community"[19]	"Effects of flipped classrooms integrated with MOOCs and game-based learning on the learning motivation and outcomes of students from different backgrounds"[20]	"Flipping the Math Classroom for Non-Math Majors to Enrich Their Learning Experience"[21]	"The Impact of the Flipped Classroom on Mathematics Concept Learning in High School"[22]
Subject	76 students	96 students	238 students	82 students	82 high-school students
Country	Hongkong	Indonesia	Taiwan	USA	Taiwan
Method	Mixed method	Mixed method	Mixed method	Mixed method	Quasi-experimental
Instrument	Test and Interview	Questionnaire, observation, test, and interview	Test and questionnaire	Test and questionnaire	Test and questionnaire
Dependent Variable	Mathematics achievement and cognitive engagement	Creative thinking	Learning motivation and outcome	Problem solving skill and student's confidence	Learning achievement and motivation
Result	"The test results indicate that students in the flipped class (n = 28) significantly outperformed those in the traditional (n = 27) and online independent study (n = 21) classes. In addition, flipped learning with gamification promoted students' cognitive	"The results of this research show that (1) the mathematics learning instruments were valid, practically, and effective, and (2) the Kruskal Wallis test obtained significance value 0.017 ($p<0,05$), which indicated the implementation of	"Flipped classrooms integrated with MOOCs and game-based learning can enhance students' learning motivation and outcomes. Specifically, compared with students with high self-confidence in learning mathematics, students with low and medium levels	"The flipped classroom students outperform their traditional lecture peers on exams, especially in terms of their mathematical problem-solving skills. The flipped classroom students are also more confident than their traditional lecture peers about their abilities and their	"Findings indicated a significant difference in the learning achievement and motivation between the two groups with students performed better using the flipped classroom. Further analysis showed a significant

	engagement better than the other two approaches."[18]	the flipped classroom-blended learning model based on lesson study for learning community has significant effect on students' creative thinking skill."[19]	of self-confidence showed significantly greater improvement in overall learning motivation."[20]	understanding of the course material, crediting their understanding primarily to the in-class activities, which are made possible because the flipped classroom design promotes an experiential, active-learning environment without compromising content."[21]	difference in the performance of low achievers in the experimental and control groups."[22]

The several studies indicated that effective flipped classroom in mathematics can improve academic result [23]. Academic result can be interpreted with mathematics performance, learning outcome or mathematics achievement. Not only academic result but also it can improve student's self-confident [7]. Based on research by Wei at al stating that flipped classroom significantly improved student's mathematics performance [17]. This research used experimental method and examined 88 students in China. Accordance with Lo and Hew's research, mathematics achievement was improved by implementing flipped classroom which examined 76 ninth grade students in Hongkong [18]. Other than mathematics achievement, student cognitive engagement of experimental group was better than the others [18]. The research of flipped classroom effect conducted by Hung, Sun and Liu tested 238 Taiwanese junior high school students with the result that learning outcome (mathematic achievement) and motivation increased [20]. This finding confirmed by the research of Bhagat et al which stated that student learning achievement and motivation significantly increased as using flipped classroom [22]. The quasi-experimental method was used in this research with 82 high school students in Taiwan.

Research conducted by Al-Zoubi and Suleiman on 54 undergraduate students in Saudi Arabia found that flipped classroom can improved critical thinking skills [15]. Mixed method was used in this research with test and interview instrument. This finding is accordance with research result of Atwa et al, critical thinking skills can be improved by flipped classroom [13]. This research used quasi-experimental method by examining 385 students and interviewing 16 teachers in Palestine. Outside class activity in flipped classroom might allowed student to explore knowledge critically. Providing fundamental material before class make student more prepared to engage in depth discussion that involve judging, analyzing, and creating[24]. Therefore, implementation of effective flipped classroom can improve student critical thinking skills.

Research conducted by Gao and Hew found that computational thinking skill can be improved by flipped classroom [16]. The experimental method with test and interview instrument was used and 125 Hongkong students were tested in this research. The key factors including collaboration, learning motivation and learning strategy in flipped classroom influence computational thinking skills [25]. Collaboration or student to student connectedness can encourage peer interaction to solve the problem in computational thinking skills. Student centered learning, giving fundamental material outside of class and activities in class encourage student's learning motivation. Therefore, activities in flipped classroom can stimulate computational thinking skills.

Based on research by Sya'roni et al, flipped classroom can improved creative thinking skill [19]. This research used mixed method and examined 96 students in Indonesia using test, observation, questionnaire, and interview instrument. Other research also found that flipped classroom effectively encourage student's creativity [26]. A well-designed flipped classroom allows student to be elaborative, flexible and fluent in their ideas [26]. Visualization allows to create the chance of creativity [27]. Visualization like video or presentations given outside of class in flipped classroom stimulate creative thinking skill. Activities in class allows student's ideas to be elaborative and fluent.

Research conducted by Ishartono et al stated that self-regulated learning increased in flipped classroom group. The experimental method with questionnaire instrument was used and 60 Indonesian undergraduate students were tested in this research. This finding is accordance with previous research stated that flipped classroom can improved self-regulated learning and contributed in digital learning[28]. Flipped classroom allows student to explore independently outside of class. Providing student space was one of flipped classroom principle [8]. Therefore, flipped classroom can stimulate student self-regulated learning.

Based on the above research, it can be concluded that the implemented of Flipped Classroom has grown in several countries such as Indonesia, Taiwan, Hongkong, Jordan, Saudi Arabia, USA, China, Palestine [13][14][15][16][17][18][19][20][21][22].

4. Conclusion

The results of study selected in this article aim to look at the effects of using Flipped Classroom in mathematic. Flipped classroom was be implemented from elementary school to college in mathematics education. A quasi-experiment, experiment, and mixed-methods were used in research methods. The instruments used in this study are a test, questionnaire, interviews. All studies report improvements in mathematics achievement, learning motivation, critical thinking skills, creative thinking skills, computational thinking skills, learning motivation and self-regulated learning.

Based on the result, researcher investigated student achievement by observing the significance of pre-test and post-test scores in experimental group compared to the control group. The questions in the open interview revealed the students' perspectives regarding the use of the flipped classroom in mathematics course, the results of the interview showed the students were more motivated and enthusiastic in participating outclass and in-class learning.

The research results in this study reveal the fact that the implementation of flipped classroom has the potential to improve student achievement and skills. However, there are some challenges that to be needed for effective implementation of flipped classroom. First, it is necessary to using accessible technology to student. Second, the quality of learning media, like a quality video that stimulate student to build the concept and easy to understand. Third, instructor could examine the technology availability and student competency. Moreover, instructor should design the interactive activities inside classroom.

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