DEVELOPMENT OF FLIPPED CLASSROOM STRATEGY INTEGRATING STEM APPROACH MODULE IN TEACHING BASIC MATHEMATICS CONCEPTS AMONG PRE-SERVICE ELEMENTARY TEACHERS

RUSNILAWATI

SULTAN IDRIS EDUCATION UNIVERSITY
2025

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THESIS PRESENTED TO QUALIFY FOR A DOCTOR OF PHILOSOPHY

FACULTY OF HUMAN DEVELOPMENT
SULTAN IDRIS EDUCATION UNIVERSITY

2025

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ACKNOWLEDGMENT

I am grateful to Allah SWT for His blessings and guidance that enabled me to complete this thesis entitled "DEVELOPMENT OF FLIPPED CLASSROOM STRATEGY INTEGRATING STEM APPROACH MODULE IN TEACHING BASIC MATHEMATICS CONCEPTS AMONG PRE-SERVICE ELEMENTARY TEACHERS". This research and development study was conducted to help improve the quality of education, particularly in the Basic Mathematics Concept Course among prospective elementary school teachers. I owe a profound debt of gratitude to all those who guided, encouraged, and sustained me throughout my journey in crafting this thesis. My deepest appreciation goes to Assoc. Prof. Dr. Siti Rahaimah binti Ali, my esteemed supervisor, whose unwavering guidance, direction, and belief in me made this endeavor possible. I am further indebted to: 1) Professor Dato' Dr. Md Amin bin Md Taff, Vice Chancellor of Universiti Pendidikan Sultan Idris, Malaysia, and his team, for their wisdom and for providing resources that nourished this undertaking; 2) Prof. Dr. Sofyan Anif, M.Si., Rector of Universitas Muhammadiyah Surakarta, and his staff; 3) Assoc. Prof. Dr. Raja Nor Safinas binti Raja Harun, Dean of the Institute of Graduate Studies, and Assoc. Prof. Dr. Abdul Talib bin Mohamed Hashim, Dean of the Faculty of Human Development; 4) Dr. Fitri Puji Rahmawati, M.Pd., M.Hum., Head of the Elementary School Teacher Education Study Program at Universitas Muhammadiyah Surakarta, and the program's faculty; 5) Dr. Mazarul Hasan Mohamad Hanapi, my co-supervisor; 6) My cherished husband, Farizky Rahman, and my beloved son, Fadyl Putra Nilazky, whose constant encouragement and unwavering faith in me were my pillars of strength; 7) My dearest parents, Sugiyarto and Raspinah, Samna and Siti Wahidah, and my extended family; 8) My fellow PhD students at UPSI, especially Dhany Efita Sari and Siti Hadiyati Nur Hafida, whose camaraderie and encouragement spurred me on to give my best; and to all others who, in countless ways, contributed to the completion of this research, my heartfelt gratitude. I hope that my efforts may leave a positive mark on the field of education.
Finally, from the depths of my heart, thank you.

ABSTRACT

This study aimed to create and evaluate the effectiveness of a Flipped Classroom Strategy integrating STEM Approach (FCS-SA) module. The module was designed to enhance cognitive abilities, attitudes, and problem-solving skills among pre-service elementary teachers. The research methodology employed was Development Research, utilizing the 4-D development Module, which includes four stages: Define, Design, Develop, and Disseminate. In the limited trial, 55 students participated as respondents. For the field trial, the respondents comprised 106 students in the experimental group and 104 students in the control group. Both groups underwent learning processes using their respective intervention Modules. The research instruments included validation sheets, teacher practicality assessment sheets, student assessment sheets, cognitive tests, problem-solving ability tests, attitude questionnaires towards mathematics, and learning implementation observations. Seven hypotheses were tested in this study, with hypotheses 1, 2, and 3 analyzed using the the Wilcoxon Signed Rank Test. Hypotheses 4, 5, and 6 were examined using The Kruskal-Wallis test, while hypothesis 7 underwent MANOVA analysis. The validation results indicated that the FCS-SA Module was highly suitable for use. The trial results demonstrated that the developed FCS-SA Module was both practical and effective. The findings revealed that the FCS-SA Module effectively improved cognitive abilities, attitudes, and problem-solving skills simultaneously. Moreover, the FCS-SA Module significantly influenced each aspect ($p<0.001$). Following N-Gain testing, a substantial effect size was demonstrated in the cognitive aspect ($d= 2.024$) and problem-solving skills ($d= 0.80$). The smallest effect size was observed in the attitude aspect ($d= 0.43$). Students with a moderate attitude category exhibited significant differences in problem-solving and cognitive abilities. However, students with low and high cognitive categories did not show significant differences in the problem-solving aspect. Furthermore, it is recommended that lecturer conduct early diagnostic assessments to provide appropriate learning steps based on the diverse abilities of pre-service elementary teachers.

PEMBANGUNAN MODUL STRATEGI FLIPPED CLASSROOM YANG MENGINTEGRASIKAN PENDEKATAN STEM DALAM PENGAJARAN KONSEP ASAS MATEMATIK DALAM KALANGAN BAKAL GURU SEKOLAH RENDAH

ABSTRAK

Kajian ini bertujuan untuk membangunkan dan menilai keberkesanan modul Strategi Pembelajaran Terbalik yang mengintegrasikan Pendekatan STEM (FCS-SA). Modul ini direka bentuk untuk meningkatkan keupayaan kognitif, sikap, dan kemahiran menyelesaikan masalah dalam kalangan bakal guru sekolah rendah. Metodologi penyelidikan yang digunakan ialah Penyelidikan Pembangunan dengan menggunakan Module pembangunan 4-D yang merangkumi empat peringkat: Menentukan, Mereka Bentuk, Membangunkan, dan Menyebarkan. Dalam ujian terhad, seramai 55 pelajar terlibat sebagai responden. Bagi ujian lapangan, responden terdiri daripada 106 pelajar dalam kumpulan eksperimen dan 104 pelajar dalam kumpulan kawalan. Kedua-dua kumpulan menjalani proses pembelajaran menggunakan Module intervensi masing-masing. Instrumen penyelidikan termasuk lembaran penilaian pengesahan, lembaran penilaian keberkesanan pengajaran oleh pensyarah, lembaran penilaian pelajar, ujian kognitif, ujian keupayaan menyelesaikan masalah, soal selidik sikap terhadap matematik, dan pemerhatian terhadap pelaksanaan pembelajaran. Tujuh hipotesis telah diuji dalam kajian ini, dengan hipotesis 1, 2, dan 3 dianalisis menggunakan Ujian Wilcoxon Signed Rank. Hipotesis 4, 5, dan 6 dikaji menggunakan ujian Kruskal-Wallis, manakala hipotesis 7 dianalisis menggunakan MANOVA. Keputusan pengesahan menunjukkan bahawa Modul FCS-SA sangat sesuai untuk digunakan. Hasil ujian menunjukkan bahawa Modul FCS-SA yang dibangunkan adalah praktikal dan berkesan. Penemuan kajian mendedahkan bahawa Module FCS-SA berkesan dalam meningkatkan keupayaan kognitif, sikap, dan kemahiran menyelesaikan masalah secara serentak. Selain itu, Module FCS-SA memberi kesan yang signifikan terhadap setiap aspek ini ($p<0.001$). Selepas ujian N-Gain dijalankan, saiz kesan yang ketara ditunjukkan dalam aspek kognitif ($d = 2.024$) dan kemahiran menyelesaikan masalah ($d = 0.80$). Saiz kesan yang paling kecil diperhatikan dalam aspek sikap ($d=0.43$). Pelajar dengan kategori sikap sederhana menunjukkan perbezaan ketara dalam keupayaan menyelesaikan masalah dan kognitif. Walau bagaimanapun, pelajar dengan kategori kognitif rendah dan tinggi tidak menunjukkan perbezaan ketara dalam aspek penyelesaian masalah. Selain itu, disarankan agar pensyarah menjalankan penilaian diagnostik awal bagi menyediakan langkah pembelajaran yang sesuai berdasarkan kepelbagaian keupayaan bakal guru sekolah rendah.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
C	Control group (routine strategy group)
CLA	Collective learning aspects
CLO	Course Learning Outcomes
DV	Dependent Variable
EDP	Engineering Design Process
FCS	Flipped Classroom Strategy
FCS-SA	Flipped Classroom Strategy Integrating STEM Approach
HOTS	Higher Order Thinking Skills
ICT	Information and Communication Technology
IRR	Inter-Rater Reliability
IT	Informational Technology
IV	Independent Variable
LMS	Learning Management System
LOTS	Low Order Thinking Skill
MANOVA	Multivariate Analysis of Variance
NAQ	Needs Analysis Questionnaire
MHP	Micro Hydro Power
PBL	Problem-Based Learning
PISA	Program for International Student Assessment
PSS	Problem Solving Skill

PSTT	Primary School Teacher Training
RQ	Research Questions
R&D	Research and Development
SEM	Standard Error Measurement
SPSS	Statistical Packages For The Social Science
STAD	Student Teams Achievement Divisions
STEM	Science, Technology, Engineering, and Mathematics
TIMSS	Trends in International Mathematics and Science Study
UMS	Muhammadiyah University of Surakarta
X	Experimental Class

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Mathematics plays a crucial role in shaping the progress of a nation, yet its abstract nature often creates challenges for pre-service elementary teachers in understanding and applying its concepts. Lecturers are therefore encouraged to adopt approaches that integrate science and technology in order to build students' independent knowledge and problem-solving skills. The rapid development of technology demands that lecturers continuously adapt their methods to foster students' ability to think critically, creatively, and logically in real-life contexts. Observational findings have shown that, particularly in online learning environments, pre-service elementary teachers still face considerable difficulties in analyzing mathematical problems, especially story problems. Despite generally positive attitudes toward mathematics, their problem-solving skills remain limited and require further development. This condition highlights the urgency of innovative learning models that can engage pre-service elementary teachers more effectively and optimize the use of information technology.

One promising solution is the integration of the STEM approach with the Flipped Classroom Strategy, which combines science, technology, engineering, and mathematics with technology-driven, student-centered learning. The STEM approach emphasizes critical thinking, collaboration, communication, creativity, and digital literacy, all of which are essential for 21st-century pre-service elementary teachers. Meanwhile, the Flipped Classroom Strategy enables students to learn content independently outside the classroom through videos, online discussions, and digital resources, allowing class time to be devoted to deeper engagement and problem-solving. Previous practices in online mathematics learning have often been limited to assignments, without adequately fostering conceptual understanding or problem-solving abilities. By integrating STEM with the Flipped Classroom, pre-service elementary teachers are expected to develop stronger mastery of basic mathematical concepts while also enhancing their attitudes toward mathematics. Ultimately, this innovation aims to prepare pre-service elementary teachers with the necessary skills and mindsets to become effective educators in the technology-driven era.

1.2 Research Background

Currently, education has developed from teacher-centered learning to student-centered learning. Teachers act not only as knowledge providers but also as learning promoters, who encourage students to build knowledge actively (Serin, 2018). Meanwhile, students are directed to learn independently through collaboration and inquiry activities. In this case, teachers need to use innovative learning Modules so that students can be actively involved in learning the mathematical concept. In order to develop students' skills in the 21st century, teachers need to combine science, mathematics, and

technology (Yip, 2020). This combination is a form of learning in the 21st century, where information can be obtained easily to help increase student activity in classroom learning activities.

The increasingly rapid development of science and technology requires every human being to adapt themselves to keep up with the changes that occur and solve the problems they face carefully, precisely, and creatively. At present, technological developments lead to digital social networks and the use of gadgets (Sardone, 2018). To keep up with the demands of science and technology development, university students need to understand and train themselves to be skilled in solving problems that arise in daily life. Through the use of technology, learning can be carried out more interactively and attractively. Students can broaden their horizons anywhere and anytime with the help of internet networks and gadgets.

Many universities have developed online mathematics learning resources, software, e-books, etc. Online learning in Indonesia has been further enhanced following the COVID-19 pandemic to prevent the spread of the COVID-19 virus. Online learning makes it easy for educators to share material and discuss synchronously/asynchronously (Rinekso & Muslim, 2020). Besides, mathematics learning designed with the collaboration of mathematics and technology has been proven to be more effective in improving students' problem-solving abilities, attitudes, and cognitive (Sardone, 2018). In this regard, the basic mathematics concept course is one of the subjects that must be taken by students at the Primary School Teacher Training Program, Universitas Muhammadiyah Surakarta. Online learning is a learning concept being developed at Universitas Muhammadiyah Surakarta. Based on the

observations and interview results with students at the Primary School Teacher Training Program, Universitas Muhammadiyah Surakarta, the e-learning process still tended to only give online assignments so that students encountered difficulty understanding mathematical concepts.

1.2.1 Mathematics in the 21st century

The development of mathematics has an essential role in advances in the fields of engineering, biomedical science, commerce, and information technology (Niss & Højgaard, 2019). Besides, mathematics also has a vital role in a nation's development. 21st-century mathematics encourages students to be able to ask critical questions and take risks. Mathematics learning climate must be able to motivate students to learn regardless of sex, race, handicapping conditions, or socioeconomic status. Moreover, mathematics has a major contribution to the STEM approach (Beswick & Fraser, 2019). The STEM approach is considered an opportunity to innovate in mathematics learning. Teachers are expected to contribute to building a STEM literate community (Fitzallen et al., 2019).

Mathematics is a science that comes from human thinking results related to ideas, processes, and reasoning. Mathematics originates from human experiences in everyday life; then, concepts are generated through these experiences' analysis and synthesis process. Mathematical concepts tend to be abstract, so it is necessary to make efforts to build student knowledge independently with an approach that links science and technology. Further, the 21st-century skills that need to be taught to students

encompass critical thinking, teamwork, problem-solving, creativity, analytic reasoning, and communication (Akcanca, 2020). These skills empower students to oversee their well-being, cultivate positive relationships, make informed decisions about their lives, develop into ethical and integral citizens, engage in effective cross-cultural communication, contribute to the collective welfare, and demonstrate responsibility at local, regional, and global levels (Fitzallen et al., 2019). Hence, mathematics in the 21st century urges individuals to think critically and innovatively through the use of various digital literacies, which can be studied anywhere and anytime. Understanding mathematical concepts are crucial for students to be able to solve problems with a variety of strategies.

Teachers need to use an appropriate learning Module to increase emphasis on problem-solving, implementation, and high order thinking skills. Mathematics learning activities need to be directed to build knowledge-based on students' previous experiences. Students learn to get ideas and information through experiences. Besides, mathematics learning needs to be accustomed to using technology appropriately, especially calculators and computers (Sardone, 2018). Mathematics teaching should be more frequently directed towards open-ended projects and cooperative learning groups. Learning mathematics should introduce students to the history of mathematics and its relation to other disciplines. Some of the challenges teachers need to face in 21st-century mathematics learning are adapting mathematics material to new science and technology developments, accelerating programs for sustainable teacher professional development, and developing new assessment instruments that reflect new hopes for mathematics education (Kaomea, 2019). To address these challenges, teachers must adopt innovative approaches that align with 21st-century learning skills, such as the

STEM approach, which fosters creativity, collaboration, communication, and critical thinking.

1.2.2 STEM Approach

Teachers are increasingly geared towards teaching in keeping with the development of 21st-century learning skills for students (Sardone, 2018). The four abilities that need to be developed in 21st-century learning include creativity, collaboration, communication, and critical thinking (Beswick & Fraser, 2019). The STEM approach contributes to the development and application of these skills through an inquiry-based learning approach. The STEM approach is designed to improve the quality of a nation's learning to excel in the fields of science, technology, economics and have the power to compete globally through systemized education. This approach connects multidisciplinary science into an integrative whole. The teacher directs students to deepen their understanding of concepts so that they can integrate theoretical understanding and skills. Therefore, the development of student skills is an aspect that is of great concern in implementing the STEM approach.

STEM is an interdisciplinary approach that directs students to use science, technology, engineering, and mathematics in the context of real problems and correlates with relevant experiences that students need in the world of work in the future (Holmlund et al., 2018). The STEM approach consists of science aspects, technological aspects, engineering aspects, and mathematics aspects. The science aspect is the skill to use the knowledge and scientific processes to understand natural phenomena and

manipulate these symptoms so that they can be implemented (Martín-Páez et al., 2019). Technology aspects are students' skills in knowing how new technology can be developed, what skills to use technology, and how technology can be utilized to facilitate human work. The engineering aspect is the knowledge to operate or design a procedure to solve a problem. Meanwhile, mathematics aspects are skills used to analyze, provide reasons, communicate ideas effectively, solve problems, and interpret solutions based on calculations and mathematical data (Bicer et al., 2017).

The challenge faced with applying the STEM approach is that it requires many resources, media, and more time to collaborate in designing classroom learning. Some aspects that should be taken into account in the STEM approach application comprise a focus on the integration of multidisciplinary knowledge in an integrated manner in realizing more meaningful learning, using current relevant themes (for instance, global issues and environmental pollution), cultivating a sense of sensitivity to care for issues global so that it becomes a problem solver for these problems, strengthens 21st-century skills, develops skills (literacy, problem-solving skills, creativity skills, collaboration), and employs problem-based and project-based learning approaches (Milaturrahmah et al., 2017). The fundamental skills as the focus of the STEM approach are critical thinking, collaboration, communication, creativity, problem-solving, data literacy, digital literacy, and computer science.

STEM possesses a pattern known as the EDP (Engineering Design Process) or the process of designing work or machine. EDP has many versions that have been formulated by experts; however, in general, EDP has the following pattern: 1) define the problem, 2) plan solutions, 3) make a Module, 4) test the Module, and 5) reflect and

redesign. Teachers have to take steps in the STEM approach: 1) identifying content standards, 2) identifying essential questions/driving questions, 3) establishing what the student knows and creating multiple and ongoing assessment opportunities, and 4) designing interdisciplinary learning activities. The STEM approach is a perfect match between problems that occur in the real world and problem-based learning (Sutaphan & Yuenyong, 2019).

For this reason, STEM learning needs to emphasize several aspects of the learning process (Falloon et al., 2020) covering 1) asking questions (science) and defining problems (engineering), 2) developing and employing Modules (engineering), 3) planning and conducting investigations (science), 4) analyzing and interpreting data (mathematics), 5) using mathematics, information technology, and computers and computational thinking (technology), 6) building explanations (science) and designing solutions (engineering), 7) engaging in arguments based on evidence (mathematics), and 8) obtaining, evaluating, and communicating information (engineering). Building on the STEM approach's emphasis on problem-solving and inquiry-based learning, the Flipped Classroom Strategy offers an innovative method to further enhance student engagement and critical thinking by shifting direct instruction outside the classroom and prioritizing interactive, student-centered learning experiences.

1.2.3 Flipped Classroom Strategy

The Flipped Classroom Strategy has become an innovative learning Module in recent years. Flipped learning is a student-centered learning Module. This learning Module

involves students actively in interactions between students and students and between students and teachers in a meaningful way (Parra-González et al., 2020). Students are asked to view and review learning content before entering class. Flipped learning provides more time for students and teachers to engage in individual learning and small group learning (Burke & Fedorek, 2017). Learning activities in class are more focused on group discussion activities, solving problems, and generating new ideas (R. Farida et al., 2019). This learning Module aims to build a culture of independent learning and critical thinking.

In traditional learning, students are given material first and then asked to apply the concept by giving homework. In contrast to traditional learning, flipped learning gives students homework first and then takes students to discuss in class. The learning implementation focuses on directing students to apply knowledge and achieve a higher learning objective level (Burgess et al., 2018). Traditional learning makes students passive and feels bored because teachers tend to control the class and deliver material through lectures. University students listen more to the lecturer's explanation and occasionally ask questions or nod, pretending to understand (R. Farida et al., 2019). This problem can be overcome by changing the classroom teaching method into learning videos that can be listened to anytime and anywhere. Conventional learning, which is transferred into video form, will make it easier for students to repeat the video's explanation according to their needs (Zainuddin, Habiburrahim, et al., 2019). One of the newest digital-based learning Modules currently using instructional videos as a learning medium outside the classroom is the Flipped Classroom Strategy (DeLozier & Rhodes, 2017).

The Flipped Classroom Strategy becomes a technology-based learning Module that aims to increase student involvement in the learning process and make the delivery time more efficient (Zainuddin, Hermawan, et al., 2019). The Flipped Classroom Strategy is one of the learning innovations with the concept of e-learning (Hamid, 2020). The teacher is in charge of making materials in writing, narration, video, podcasts, and various other media that students can reach outside the classroom. Activities usually carried out in the classroom, such as explaining the material, giving assignments, question training, and homework, are transferred to online learning. Before entering the classroom, students already have several pieces of information that come from the material content studied online. Activities in the classroom are more dominant in case study activities, problem-solving, lab tests, practicum, games, simulations, and experiments (Akçayır & Akçayır, 2018). Thus, students are no longer bored and tired of listening to lectures from the teacher.

The Flipped Classroom Strategy application puts remembering and understanding stages as a cognitive level carried out outside the classroom by observing various material content accessed online. Learning activities in the classroom are conducted for learning at the cognitive level, namely applying, analyzing, evaluating, and creating (Zainuddin & Halili, 2016). In order for the flipped learning application to run optimally, teachers need to make several preparations, including ICT skills, online learning media (e-books, videos, recordings), adequate technology devices (computers, laptops, cellphones), and a stable internet network (video call, streaming, etc.) (Hamid, 2020). Five positive reasons for applying the Flipped Classroom Strategy according to Millard are (1) increasing student involvement in the learning process, (2) strengthening team performance-based skills, (3) offering an educator approaches to students

personally through guidance, and (4) student activities such as class discussions become more focused (Schmidt & Ralph, 2016). The Flipped Classroom Strategy is beneficial for teachers who lack time in teaching material (Hamid, 2020). This learning Module application is very appropriate for students who can take advantage of technology and adapt to the educational content presented by the teacher.

Several studies have proven that flipped learning has advantages to be applied to classroom learning. Flipped learning can improve critical thinking skills (Lee, 2018). Students are asked to review learning content at the pre-learning stage. Furthermore, students conduct group discussions in class, then expand their learning activities after class is finished. Students can spend a lot of time deducting, explaining, and evaluating knowledge related to the learning material. Incorporating flipped learning in e-learning can stimulate creativity when students discuss or solve problems together with peers (Strelan et al., 2020). Based on the research results, the Flipped Classroom Strategy has the potential to be applied in teaching and learning activities in higher education (R. Farida et al., 2019).

The results revealed that the Flipped Classroom Strategy usually makes use of IT-based multimedia, such as video and YouTube, to develop students' interest in studying the material before learning (Hamid & Effendi, 2019). Based on the research results on student learning styles, 60% of students had visual learning styles, 27% had auditory learning styles, and the rest had kinesthetic learning styles. These results can be used as material for consideration in blended learning by applying the Flipped Classroom Strategy (Effendi et al., 2017). Teachers can employ the Learning Management System (LMS) to create virtual classes as online learning so that students

are active and independent in learning anywhere and anytime (Kurniawati et al., 2019) (Nurfadillah et al., 2020). Teachers can utilize virtual classes to share material with students in the form of YouTube video links or narrative power points and create asynchronous discussion links. Based on the research results, YouTube learning videos can improve high order thinking skills, students' understanding of the material, and teacher creativity in teaching (Nomleni & Manu, 2018; Pambudi et al., 2019; Pratiwi & Puspito Hapsari, 2020; Sudiarta & Sadra, 2016). Integrating IT-based multimedia in the Flipped Classroom Strategy not only enhances students' engagement and higher-order thinking skills but also aligns with the broader goal of mathematics education in fostering critical, logical, and creative thinking—essential skills for navigating advancements in science and technology.

1.2.4 Cognitive

Learning mathematics has a vital role in dealing with advances in science and technology by cultivating various skills that involve the ability to think critically, logically, creatively, and collaboratively. Article 3 of Law Number 20 of 2003 concerning the National Education System states that national education has the function of developing capabilities and shaping a nation's character and civilization with dignity in the framework of educating the nation's life. Besides, education aims to develop students' potential to become human beings who believe in and fear God Almighty, have a noble character, are healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens (Umami, 2018). Regarding this, university students as elementary school teacher candidates need to have good cognitive abilities in mathematical concepts (Verschaffel et al., 2017). Based

on the research results, cognitive and affective-motivational teacher variables play an essential role in improving mathematics learning quality (Baier et al., 2019). Also, mathematics learning needs to apply cognitive principles, including scaffolding, distributed practice, feedback, worked examples, interleaving, abstract and concrete representations, error reflection, and analogical comparison (Booth et al., 2017).

The students' potentials that should be improved in learning mathematics cover cognitive, affective, and psychomotor aspects (Codreanu et al., 2020). These three aspects own a crucial role in creating a smart and character generation of the nation. Therefore, so that the process of developing students' potential can provide maximum results, learning activities must cover these three aspects. Learning activities are the process of changing students' behavior by optimizing the environment as a source of learning stimulus. Government Regulation Number 19 of 2005 Article 19 paragraph 1 concerning National Education Standards explains that the learning process must be carried out in an interactive, inspiring, fun, challenging, and motivating way for students (Umami, 2018). Thus, the mathematics learning process should provide opportunities for students to play an active role in building their knowledge.

The purpose of learning mathematics is to achieve optimal learning outcomes. Learning outcomes are specific competencies or abilities, both cognitive, affective, and psychomotor, achieved or mastered by students after participating in the teaching and learning process (Wahono et al., 2020). Consistent with this, the feelings and emotions one has in solving a mathematics problem influence not only the students' immediate attainment of cognitive learning outcomes but also their using mathematics confidently in the future to solve real-world problems (W. L. Ng et al., 2019). Individuals' feelings

and emotions in solving math problems can affect cognitive students' learning outcomes and self-confidence in solving real-world problems. In addition, the critical thinking skills of mathematical students are influenced by cognitive style. The teacher needs to facilitate students' learning that develops critical thinking, especially for students with dependent cognitive styles (Agoestanto et al., 2016).

Mathematical thinking processes are based on two very different kinds of representational transformations. Conceptual understanding in mathematics involves a synergy of a two-register synergy and sometimes a three-register synergy (Verschaffel et al., 2017). The construction of mathematical knowledge can be cognitively complex and requires the development of specific awareness of registers' coordination. In this case, teachers need to have a deep understanding of mathematics and its importance when teaching a wide variety of math skills (Hudson et al., 2018). Study results exposed that math anxiety could interfere with students' ability to use reasoning and was associated with the inflexible use of strategies (Jiang et al., 2020).

Students' mathematics achievement and cognitive abilities taught by flipped learning were better than students taught by traditional learning and independent online study (Lo & Hew, 2018). Mathematical skills were significantly correlated with sustained attention, inductive reasoning, math anxiety, and working memory. The study's outcomes have verified that sustained attention, inductive reasoning, working memory, and math anxiety were correlated with students' mathematical performance (Pappas et al., 2019). Given the strong connection between cognitive and affective factors in mathematics learning, fostering a positive attitude toward mathematics is crucial for enhancing students' achievement and engagement, as it helps mitigate math

anxiety and supports the development of essential reasoning and problem-solving skills.

1.2.5 Attitude towards Mathematics

The process of learning mathematics is strongly influenced by affective factors, namely beliefs, emotions, values, and attitudes (Bishop, 2017). In order for students to be active in learning mathematics, a positive attitude towards mathematics is needed. An important aim of mathematics education is to develop in students positive attitudes towards mathematics (W. L. Ng et al., 2019). Besides, students 'attitude towards mathematics has been a factor known to influence students' achievement in mathematics (Al-Mutawah & Fateel, 2018). It is advisable that students' attitude be enhanced as this will translate into improve academic achievement in the subject (Al-Mutawah & Fateel, 2018).

The attitude domain in the teaching and learning process aims at making the students know "why". The skill domain is designed to make them know "how". Meanwhile, the knowledge domain aims at making them know "what". The final result is the improvement and balance of the ability to be good human beings (soft skills) and to be the ones having skills and knowledge to live decently (hard skills) including attitude, knowledge, and skill competencies (Umami, 2018). Attitude is the expression or response of students regarding learning. Attitudes in the form of expressions of like, dislike, or rejecting an object (Astalini et al., 2019). The attitude towards mathematics has to do with likes and dislikes, the belief that it is good or bad, and the belief that it

is useful or not. Teachers are often concerned if not frustrated, about their students' dislike or fear of mathematics (Guce, 2018). It is often considered to be an irrelevant or unpopular subject. Some efforts have been made to increase students' engagement in mathematics learning and increase their attitude toward mathematics.

Positive attitudes towards mathematics could increase academic achievement and learning (Chen et al., 2018). There is a positive relationship between students' attitudes, motivation, and discipline. Therefore, teachers need to implement the learning that fosters attitudes, motivation, and discipline of students in learning (Darmaji et al., 2019). The attitude towards mathematics has a role in learning the material. The attitude cannot be separated from teaching and learning since it is derived from the learning process. Teachers can use some pleasant learning innovations to enhance students' attitudes to mathematics (Guce, 2018). One of the innovations that can increase it is the use of technology, games, audiovisual media, video, PowerPoint, and YouTube (Higgins et al., 2017; Turkmen & Soybas, 2019). Since positive attitudes towards mathematics contribute to academic success, teachers should integrate engaging learning innovations—such as technology, games, and multimedia—to enhance students' motivation and problem-solving skills, which are essential for both mathematical understanding and future STEM careers.

1.2.6 Problem-Solving Skills in Mathematics

Students' activeness will occur when the lecturers give them problems; therefore, they can develop their mindset, put forward their ideas, etc. They can think and reason a

mathematics problem when they comprehend it. Their point of view on a mathematics problem also influences the problem-solving mindset that will be applied. Teachers need to instill and develop students' attitude to problem-solving as Schroeder & Lester (Jung & Newton, 2018) explains, "problem-solving is also important because it can serve as a vehicle for learning new mathematical ideas and skills." Furthermore, problem-solving skills have a significant role in supporting STEM careers (Bicer et al., 2017). Students can think innovatively and creatively when they have good problem-solving skills.

Students need to master the concept well to understand and use mathematics in problem-solving. To be able to solve the problems well, some skills are required, including understanding problems, re-expressing those they are studying, making a completion plan, reviewing the completion steps, and estimating from incomplete information (Çakıroğlu & Öztürk, 2017; Heo & Chun, 2017). Following that, as a matter of fact, the experience in solving the problems is significant to develop students' thinking skills and help them gain more skills in solving the problem in daily life (Hadi et al., 2018). Mathematics learning should refer to concrete problem observation, semi-concrete, and problem abstraction. Therefore, mathematics learning aims at making students think critically about solving the proposed problem (Umami, 2018).

Mathematics is considered a difficult subject to understand by students in many countries and is thought to be a problematical and tedious subject (Moyer et al., 2018). Students are aware that they should make efforts and allocate much time to solve mathematics problems. The tendency to dislike math grows because of a series of unpleasant experiences experienced by some students. The experience can be the

inability to solve problems or embarrassment when a student cannot solve mathematics problems on the blackboard. Mathematics equips pupils with a uniquely powerful set of tools to understand and change the world. These tools include logical reasoning, problem solving skills, and the ability to think in abstract ways (Widodo et al., 2019). The assessment of mathematics includes three aspects, comprising affective, cognitive, and skills. However, student assessment in the mathematics classroom often focuses on cognitive learning outcomes (W. L. Ng et al., 2019). Various innovations can be applied to improve problem solving skills in mathematics, including STEM approach, the use of interactive media, and flipped learning (Ye et al., 2019; Parno et al., 2019; Soros et al., 2018). To enhance students' problem-solving skills and conceptual understanding, it is essential for lecturers to adopt innovative learning Modules that integrate technology and interactive methodologies, ensuring that mathematics education aligns with 21st-century skill requirements.

1.2.7 College Students of Primary Teacher Training Program and Learning Problems

The learning process of Basic Concepts of Mathematics at the Universitas Muhammadiyah Surakarta has been using an e-learning system of the Schoology and Open Learning programs. However, the e-learning process applied remains giving assignments online. Based on the survey results regarding the evaluation of the learning process in the basic concepts of mathematics in 2017, 2018, and 2019; the lowest assessment was found in learning methods and learning media. The learning methods applied were not optimal as those had not facilitated students in developing their skills in the 21st century. The learning process was still dominated by student presentation,

thus problem-solving skills were substandard. Based on the observation results, the 100 minutes learning process did not cover concepts well to students. Also, students considered that the subject of basic concepts of mathematics was more difficult to learn compared to other subjects. It occurred since students encountered difficulties in understanding concepts and opted to memorize mathematical formulas. Therefore, lecturers need to incorporate innovative learning Modules following the information technology developments so it is easier for students to understand concepts and they are able to develop adequate skills needed in the 21st century.

Students' attitudes towards mathematics can affect learning outcomes and achievement of learning goals (Jufrida et al., 2019; Karjanto, 2017). Based on the questionnaire results, students' attitudes towards mathematics showed a fairly good category since students did not spend more time studying besides formal class (Jufrida et al., 2019). Therefore, lecturers need to prompt students' enthusiasm in learning through sophisticated IT. One of the factors that may affect students' disposition towards mathematics is instructional and social psychological environmental factors (Mazana et al., 2019). Besides, Indonesia's mathematical literacy skills are low (Afriyanti et al., 2018). The results of the 2015 PISA study show that the mathematical literacy skills of students in Indonesia were categorized as low, earning position 64 out of 72 countries (Rahmawati, 2018). Students have insufficient skills in solving math problems that require the ability to reason, argue, communicate, and solve problems. The tendency of students to access academic content through social media and the internet, such as study materials or exam questions, was under 55% (Rahmadani, 2020). Mathematical literacy skills can be improved using ICT (Indrawati, 2020). The results of several studies show that the use of ICT in mathematics learning had a positive

impact on reasoning skills, mathematical communication, problem-solving, and mathematical connections (Rahmawati, 2018).

Mathematics learning in the 21st century aims to enable students to exhibit critical thinking, teamwork, problem-solving, creativity, analytic reasoning, and communication skills (Arifin, 2017). The results show that the problem-solving abilities of Indonesian students were poor (Kharisma & Asman, 2018; Bidasari, 2017). Based on the problem-solving stage, the most difficult stage for students to perform is planning and remembering. Based on the interview results, students found it most difficult the analyzing strategies to solve problems. At this stage, students must master the concepts and could not rely on formula memorization only. In the review stage, students encountered difficulty in finding a strategy to check the truth of the answers and strategies they used. Students were not used to working on problem-solving since the problems given tended to be cognitive problems with the Low Order Thinking Skill (LOTS) (Himmah, 2019; Yusuf & Widyaningsih, 2018; Suryapuspitarini et al., 2018). To address students' difficulties in problem-solving, particularly in planning and strategy analysis, the Basic Mathematics Concept Course should emphasize problem-solving skills through deeper conceptual understanding and higher-order thinking exercises, rather than relying solely on formula memorization.

1.3 Basic Mathematics Concept Course for Students of Primary School Teacher Training (PSTT) Program

The Basic Mathematics Concept course in the Primary School Teacher Training (PSTT) program serves as a fundamental component that prepares pre-service teachers with the

essential knowledge and skills required to teach mathematics effectively at the elementary level. This course covers a range of topics such as numbers, basic operations, fractions, geometry, measurement, and simple statistics, with an emphasis on building deep conceptual understanding rather than memorizing procedures. By engaging in this course, pre-service teachers are trained not only to comprehend mathematical ideas but also to translate them into meaningful and simplified explanations that are appropriate for young learners. Furthermore, the course helps develop students' problem-solving abilities, logical reasoning, and critical thinking, which are important in fostering active and meaningful mathematics learning in the classroom. Ultimately, the Basic Mathematics Concept course plays a vital role in equipping future primary school teachers with both mathematical competence and pedagogical readiness to implement innovative teaching strategies, including those that integrate modern approaches such as STEM and flipped classroom models.

1.3.1 Background of Basic Mathematics Concept Course for Students of Primary School Teacher Training (PSTT) Program

Students' achievement in mathematics will increase if teachers have high enthusiasm and self-efficacy in teaching the subject (Ramberg et al., 2018). Teachers have significant roles in improving students' active participation and achievement. Besides, they must be able to develop positive attitudes toward students in learning mathematics. Therefore, the students need to be proficient in 21st-century skills to teach students according to their future needs (Sardone, 2018).

The Basic Mathematics Concept Course is given to the students on a syllabus basis. It is a mandatory subject that should be taken in a semester with a 2-credit class and completed in 14 meetings. The subject is given since the students need prior knowledge of the basic concepts of mathematics, especially the ones frequently used in math learning at primary school. It studies the mathematical concepts in math learning. The concept discussion comes together with exercises designed on a problem-solving skill basis. The students are directed to understand mathematical concepts profoundly and comprehend how the concepts are applied in primary schools.

The subject may help the students comprehend several insights on the basic concepts of mathematics. The material on the course consists of 10 chapters, comprising: 1) the logic of mathematics, 2) set, 3) relations and functions; 4) natural numbers, whole numbers, and integers; 5) rational and irrational numbers; 6) the basic concept of arithmetic; 7) geometry; 8) linear equations and inequalities; 9) quadratic equations and inequalities, and 10) problem-solving. After taking the subject, the students are expected to have some provision; they can teach not only by presenting the concepts to their students but also by providing them with information about the advantages of learning math. Therefore, the school students may have a positive attitude to the subject. To be able to teach math well, the students need to learn the correct concepts in math. To ensure the effectiveness of the Basic Mathematics Concept for Primary School course, it is crucial to enhance the quality of concept delivery and material review, enabling students to build a strong foundation in mathematics and develop the skills necessary for effective teaching in primary education.

1.3.2 Teaching and Learning on Basic Mathematics Concept Course

Digital teaching is highly needed nowadays since every single student has the right to receive qualified education. The policy of "freedom of learning" enables teaching and learning to be accessed anywhere and anytime. Digital learning innovation appears due to very rapid technology development and easy-to-access information through the internet. It is the reason the government makes efforts to maximize the use of digital learning through learning source development and the online learning process. Therefore, Indonesian education can be more advanced and able to compete at the international level.

For the time being, there are several kinds of technology that can support online teaching. Some applications are used frequently in the teaching process, involving Zoom meetings, Google meetings, schoology.com, etc. Besides, various programs can be used to create digital teaching materials and tutorial videos, comprising narrated PowerPoint, OBS Studio, Camtasia, Screencast-o-Matic, YouTube, etc. Through the applications, lecturers are expected to be able to advance education and create a high-qualified generation who can compete in the technology era. The proposed digital learning innovation is the STEM Approach with the Flipped Classroom Strategy.

The Basic Mathematics Concept for Primary School course is a basic subject and the prerequisite course to take other courses, including Mathematics Education for Primary School, Mathematics Teaching and Learning for Primary School, and Mathematics and Natural Sciences Curriculum for Primary School in Muhammadiyah University of Surakarta (UMS). Also, this course received the textbook writing grant

from the university, ensuring that the learning materials received rigorous reviews. The course has applied online system using Schoology.com. However, the concept and material review need to be further developed to be genuinely qualified.

Most of the Basic Mathematics Concept Courses given to PSTT students at universities still do not apply elementary content. The class material tends to the one learned in high schools. There is a lack of linkages between the material in the courses and the real math material in primary schools. Consequently, the course of mathematics basic concept is needed to improve math teaching and learning quality, especially for the PSTT students. By performing this course, UMS might be able to improve access, quality, and relevance of the materials to generate primary school teachers who are professional and skillful in informational technology (IT). One of the skills that must be performed by a teacher in the technology era is the skill in using IT in teaching and learning. Therefore, online courses will be beneficial to encourage students to be teachers who are skillful in using IT in the classroom.

Various contents can be uploaded to schoology.com, including tutorial videos, music, narrated PowerPoint, YouTube links, etc. It also can be used to conduct online discussions. Through the course, students can easily access material for learning. The IT utilization related to learning material can be more optimal. Synchronous discussions could take place through Google Meet or Zoom meetings, and the asynchronous ones through the online discussion forums. The problem mostly found in the field is that the students still experience some difficulties in understanding the basic concept of mathematics. This is because they consider it as a demanding subject. There are still some obstacles found in online learning conducted by universities. One of the causes is

the implemented learning Modules are not suitable and not used in maximum. Besides, there are still few learning media in the form of videos or narrated PowerPoint that can be accessed anytime and anywhere. To overcome students' difficulties in understanding basic mathematical concepts, it is essential to implement more engaging and diverse learning Modules, incorporate interactive media such as videos and narrated PowerPoint, and shift from LOTS-based exercises to HOTS-oriented problem-solving activities, ensuring a more effective and meaningful learning experience.

1.4 Statement of Problems

Mathematics is considered a challenging subject because students must think analytically and critically, as well as apply reasoning to solve problems (Nurdyansyah & Aini, 2017; Andri et al., 2017; Siregar, 2017). The research results revealed that 45% of students considered mathematics to be quite difficult, and 80% said that mathematics was an essential subject. Based on PISA results, Indonesian students' mathematical abilities still ranked 63 out of 70 countries in 2015 (Siregar, 2017). This condition was caused by the learning process in the classroom that had not facilitated students to think HOTS (Purwasi & Fitiyana, 2020; Kurniawan et al., 2019; Badjeber & Purwaningrum, 2018). The practice questions provided to students still incline to be LOTS (Koto et al., 2020; Saraswati & Agustika, 2020). Various problems in learning Basic Mathematics Concepts, i.e., students still found it difficult to understand concepts due to limited learning time in class, applied e-learning still tended to provide and collect assignments online, and students memorized formulas more often and found it difficult to understand mathematical concepts. Learning in class was more focused on mastering the material

only so that the available time was inadequate to perform problem-solving exercises. Furthermore, the learning methods applied were less varied. Based on the results of the survey given to students, the learning Module received the lowest score when compared to other aspects during the last three years. The use of learning Module obtained a score of 2.9, class organization 3.2, lecture material 3.1, interaction with students 3.1, feedback to students 3.2, learning media 3.1, library and supporting materials 3.2, and satisfaction level 3.1.

Since the Covid-19 outbreak occurred, the Indonesian government has increasingly promoted the implementation of online learning, especially in universities. Universities are encouraged to improve the quality of e-learning learning. Muhammadiyah University of Surakarta has implemented an e-learning system using Schoology and open learning before the Covid-19 pandemic occurred. However, the implementation of e-learning had not been able to run optimally (Mustakim, 2020; Sagita & Khairunnisa, 2019; Pangondian et al., 2019). E-learning-based learning media was still minimal, tended to be monotonous, and only employed simple Powerpoints (Suryawan & Permana, 2020; F. Farida et al., 2019). The combination of science, technology, engineering, and mathematics in learning was still low (Rahmadhani & Wahyuni, 2018; Simatupang et al., 2019; Santoso & Mosik, 2019). It is because teachers had not mastered the steps for implementing STEM properly (Sutrisno & Hamdu, 2020; Nurhikmayati, 2019; Nessa et al., 2017). Furthermore, the teachers' ability to implement IT as a learning medium was still low (Kadarisma & Ahmadi, 2019; Rahim et al., 2019). Teachers still had difficulty operating computer programs such as Google Meet, Google Class, Zoom Meeting, Schoology, Open Learning, OBS Studio, Camtasia, and Sigil.

Students' cognitive abilities were still not maximal because the practice questions tended to be LOTS questions. Completeness of learning in the Basic Mathematics Concepts course only reached 65% in 2018 and 2019. Students still found it difficult to understand mathematical concepts and tended to memorize formulas (Syarifah, 2017). Learning in class was more focused on understanding concepts, so that time to discuss cognitive question exercises was still lacking (Dare et al., 2019). Cognitive abilities in the Basic Mathematics Concepts course still need improvements. If students do not understand mathematical concepts, students will experience difficulties in mathematics education courses and learning mathematics.

Based on the test results, students still experienced problems in solving problem-solving problems. Problem-solving activities include four stages, i.e., understanding the problem, compiling a plan, implementing the plan, and reviewing it. The most difficult stage, according to students, was the stage of planning and reviewing (Suraji et al., 2018). Based on the interview results, students found it most difficult in the stage of analyzing strategies to solve problems. At this stage, students must master the concept and cannot just memorize formulas (Kurniawan et al., 2019; Novitasari, 2016; Arifah & Saefudin, 2017; Rismawati & Hutagaol, 2018). In the retrospect stage, students had difficulty revealing ways to check the truth of the answers and strategies they use. Further, the assessment of mathematics learning still tended to be cognitive assessment (Sutama et al., 2017; Setiadi, 2016). The results showed that students' difficulties in solving mathematical problems in the form of story problems were in factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge (Novferma, 2016). Types of difficulties experienced by students were

remembering facts, remembering concepts, understanding facts, understanding concepts, applying concepts, implementing procedures, analyzing procedures, evaluating facts, evaluating concepts, evaluating procedures, and communicating metacognitive.

A positive attitude towards mathematics has a significant role in improving student learning outcomes. Students' attitudes towards mathematics were still dominant in the relatively good and low categories, namely more than 70% (Defitriani, 2019). Anxiety in the attitude domain includes being highly careful in solving problems and taking complementary actions when students run out of ideas to solve mathematics problems that are being worked on (Rizta & Antari, 2019). Therefore, the implemented learning needs to improve innovative and creative learning strategies so that students are more enthusiastic in learning and have a positive attitude towards mathematics (Raharja et al., 2019; Sobri et al., 2020; Putrianti et al., 2017).

1.5 Research Objectives

The research aimed to achieve the following objectives:

1. To analyse the elements necessary for implementing the Flipped Classroom Strategy Integrating STEM Approach in teaching Basic Mathematics Concepts among pre-service elementary teachers.
2. To design and develop the Module of Flipped Classroom Strategy Integrating STEM Approach for the Basic Mathematics Concept Course.

3. To describe the effectiveness of the Flipped Classroom Strategy Integrating STEM Approach Module on cognitive, attitudes, and problem-solving skills in the Basic Mathematics Concept Course among pre-service elementary teacher.

The more specific research objectives related to the effectiveness of the FCS-SA Module are as follows:

i. to compare the difference in the treatment group students' cognitive before and after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.
ii. to compare the difference in the treatment group students' attitude before and after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.
iii. to compare the difference in the treatment group students' problem-solving skills before and after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.
iv. to compare the difference in students' cognitive-based on attitude category between the control group after routine e-learning is implemented and the treatment group after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.
v. to compare the difference in students' problem-solving skills based on attitude category between the control group after routine e-learning is implemented and the treatment group after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.
vi. to compare the difference in students' problem-solving skills based on the cognitive category between the control group after routine e-learning is implemented and the

treatment group after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.

vii. to compare the difference in cognitive, attitude, and problem-solving skills of students between the control group after routine e-learning is implemented and the treatment group after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.

1.6 Research Questions

Based on the objectives of this study, the specific research questions are listed below:

1. What were the essential elements required for implementing the Flipped Classroom Strategy Integrating STEM Approach in teaching Basic Mathematics Concepts among pre-service elementary teachers?
2. How could the Module of Flipped Classroom Strategy Integrating STEM Approach be designed and developed for the Basic Mathematics Concept Course
3. How was the effectiveness of the Flipped Classroom Strategy Integrating STEM Approach Module on cognitive, attitudes, and problem-solving skills in the Basic Mathematics Concept Course among pre-service elementary teacher?

These more specific research questions, focusing on the effectiveness of the FCS-SA Module, are as follows:

i. Was there any significant difference between the mean scores of the treatment group students' cognitive before and after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course?

ii. Was there any significant difference between the mean scores of the treatment group students' attitude before and after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course?

iii. Was there any significant difference between the mean scores of the treatment group students' problem-solving skills before and after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course?

iv. Was there any significant difference in the mean of the scores for the students' cognitive-based on attitude category between the control group after routine e-learning is implemented and the treatment group after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course?

v. Was there any significant difference in the mean of the scores for the students' problem-solving skills based on attitude category between the control group after a routine e-learning is implemented and the treatment group after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course?

vi. Was there any significant difference in the mean of the scores for the students' problem-solving skills based on the cognitive category between the control group after routine e-learning is implemented and the treatment group after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course?

vii. Was there any significant difference in the mean scores for the cognitive, attitude, and problem-solving skills of students between the control group after routine e-learning is implemented and the treatment group after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course?

1.7 Hypotheses of the Research

The hypotheses below were formulated in alignment with the research questions related to the effectiveness of the Flipped Classroom Strategy Integrating STEM Approach on the Basic Mathematics Concept Course.

$H_0$1: There is no significant difference between the mean scores of the treatment group students' cognitive before and after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.

$H_0$2: There is no significant difference between the mean scores of the treatment group students' attitude before and after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.

$H_0$3: There is no significant difference between the mean scores of the treatment group students' problem-solving skills before and after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.

$H_0$4: There is no significant difference in the mean of the scores for the students' cognitive-based on attitude category between the control group after routine e-learning is implemented and the treatment group after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.

$H_0$5: There is no significant difference in the mean scores for the students' problem-solving skills based on attitude category between the control group after routine e-learning is implemented and the treatment group after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.

H_06: There is no significant difference in the mean of the scores for the students' problem-solving skills based on the cognitive category between the control group after routine e-learning is implemented and the treatment group after Flipped Classroom Strategy integrating STEM Approach is used on Basic Mathematics Concept Course.

H_07: There is no significant difference in the mean of the scores for the cognitive, attitude, and problem-solving skills of students between the control group after routine e-learning is implemented and the treatment group after Flipped Classroom Strategy Integrating STEM Approach is used on Basic Mathematics Concept Course.

1.8 Significance of Research

The research was necessary to increase PSTT students' math concept comprehension, positive attitude, and ability to solve problems. The students can be directed to generate digital literacy in learning the material before the class. Their independence in learning the concept may help increase problem-solving skills. They become more independent in learning activities anywhere and anytime through the e-learning system designed by the lecturer. Through the implementation of the Flipped Classroom Strategy, the researcher expected the students to maximize the use of technology to increase their learning achievement. When the problem-solving skill is developed, the positive attitude toward math becomes better. Furthermore, the STEM approach helps students to develop the ability to identify, apply, and integrate concepts from science,

technology, engineering, and mathematics to understand complex issues and have the ability to innovate in solving problems.

The objective of the research was to find out the influence of the implementation of Flipped Classroom Strategy Integrating STEM Approach viewed from cognition, attitude, and problem-solving skills in the Basic Concept of Mathematics course. The course has a significant role in establishing students' skills to be competent teachers for the 21st century. Furthermore, the STEM Approach is an approach used to adjust the learning process with IT development in the 21st century. It was expected that the results of the study can help the lecturers in teaching the basic concept of mathematics, increase positive attitude to math, elaborate problem-solving skills, and increase students' ability in using IT.

The application of Flipped Classroom Strategy Integrating STEM Approach may help lecturers increase students' involvement in a discussion (synchronous/ asynchronous) and establish knowledge independently. The lecturers can increase students' skills in using technology so that the learning becomes more interactive and interesting. Also, e-learning based teaching and learning can be conducted well and qualifiedly. Flipped Classroom provides more opportunities to lecturers to listen to opinions, difficulties, and obstacles experienced by the students in learning mathematics concepts. They can teach informational technology literate to students by combining information and communication technologies so that it can result in learning outcomes in high learning ability. The lecturers do not need to explain learning material directly as what happens in traditional learning Module implementation.

The research implemented a learning Module that prioritizes collaboration and inquiry activities so that students can be accustomed to problem-solving. The combination of science, mathematics, and technology encourages students to have 21st-century skills. Students can process digital-based information carefully, precisely, critically, and creatively through IT-based devices. The students as prospective primary teachers need to develop collaboration, communication, critical thinking, and creative thinking skills. The researcher implemented Flipped Classroom Strategy so that the students can learn more independently. Therefore, the class teaching and learning can focus on inquiry and problem-solving activities in Mathematics.

The research may provide opportunities in developing the curriculum of mathematics basic concepts to explore teaching methods focusing on concept mastery, problem-solving, and high order thinking skills. One-way teaching was conducted out of class hours in the form of video or narrated PowerPoint. The teaching and learning in class can be devoted to active learning activities, such as discussion and problem-solving. The learning activities can be managed to motivate students to think critically and become skillful to cope with math problem challenges. The learning Module provided some significant impacts to the students. First, it encouraged the utilization of information technology literacy to increase problem-solving skills. Second, it increased interaction between students and students and that of students and lecturers, and therefore it generates positive attitudes towards math. Third, STEM Approach implementation in teaching and learning could increase comprehension of the roles, advantages, and importance of mathematics in daily life. Finally, it provided enough and effective time to students in mastering mathematics basic concepts; therefore, the learning outcomes may increase.

1.9 Conceptual Framework

The conceptual framework of this study illustrates the underlying theories, principles, and relationships that guide the development of the flipped classroom strategy integrating the STEM approach in teaching basic mathematics concepts among pre-service elementary teachers. It provides a structured explanation of how the flipped classroom model, supported by STEM-based learning activities, is expected to enhance students' understanding, engagement, and problem-solving skills in mathematics. This framework is grounded in constructivist learning theory, which emphasizes active participation and knowledge construction, and it highlights the connection between innovative pedagogy, instructional modules, and learning outcomes. By presenting these interrelated components, the conceptual framework serves as a roadmap that directs the flow of the research, from the design of the module to its implementation and evaluation.

1.9.1 Routine Teaching and Learning Module

Conventional teaching and learning methods put students to mostly listen to the lecturers' explanation. Students do assignments when the teachers give them exercises (Ridha et al., 2016). The mathematics basic concept learning was implemented using an e-learning system, namely Open Learning and Schoology.com. It tended to online assignments and submission. The math concept explanation was conducted in the class,

then the lecturer gave take-home assignments. The completed assignments were then submitted through a link on Open Learning and Schoology.com.

The learning is considered not to provide students chances to develop their problem-solving and HOTS thinking skills. Most of the class hours were used to understand concepts, while the lecturers are lack time to develop students' problem-solving skills in mathematics. Some routine learning processes were considered unattractive, uncreative, and not innovative in supporting the independent learning process. There is a shortage of students' chance to convey difficulties and obstacles on math problem-solving questions. The learning methods focused more on training the students to remember, save and re-produce the received information (Amaliah et al., 2018). There was not enough time for the lecturers to understand and educate the students effectively. Besides, the use of IT-based supporting media needs to be increased. The media used still only tended to PowerPoint and LCD displaying material and exercise in face-to-face learning.

1.9.2 Components in STEM Approach

STEM is an interdisciplinary approach that directs students to use science, technology, engineering, and mathematics in the real problem context. The approach is not widely implemented in Indonesia until now. This is because teachers do not have enough comprehension about it. The obstacles experienced by the teachers in implementing the approach are relating the material to real-life and developing practice material (Milaturrahmah et al., 2017). The efforts that can be carried out is looking for

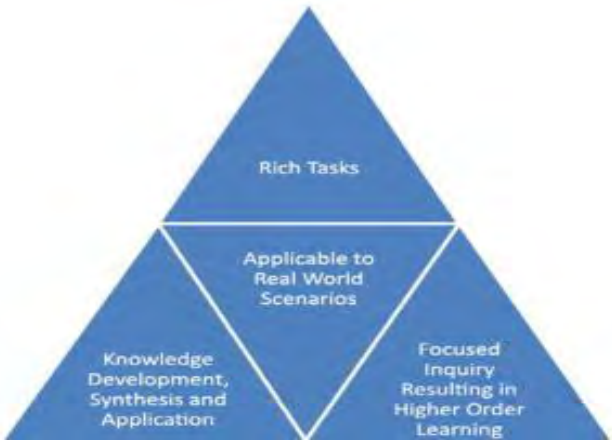
information from various sources from within the country or abroad, such as books and the internet; then, the material can be modified to be adjusted to the condition in Indonesia (Milaturrahmah et al., 2017). The steps that need to be conducted by a teacher in the STEM approach are: 1) identifying content standards, 2) identifying essential questions/ driving questions, 3) establishing what the student knows and creating multiple and ongoing assessment opportunities, and 4) designing interdisciplinary learning activities. The approach is a matching pair between problems occurring in real-life and problem-based learning (Torlakson, 2014).

Math teaching and learning using the STEM approach prioritize practice principles. Every single student should always be facilitated to exercise so that he/she gets something unforgettable as learning experiences (Awidi & Paynter, 2019). The approach emphasizes learning experiences at school, integrated learning, relations between subjects, students' skills in solving problems, thinking deeply method, the ability to manage project assignment types, the comprehension and skills on technical designs, and the use of various information and technology (Awidi & Paynter, 2019). The teaching and learning implementing experiences may increase manipulative skills and students' competencies (Fadzil & Saat, 2017). The STEM approach is interdisciplinary since it relates to some disciplines; consequently, the learning is connected, focused, meaningful, and relevant for the students (Ramadhani et al., 2019). The approach refers to problem-solving which underlies concepts and procedures of math and science, combines teamwork, uses artificial design method, and uses appropriate technology (Maass et al., 2019).

The STEM approach makes use of the characteristics of each discipline and connects one to another. The Module explained by Ramadhani et al (2019) has four main characteristics, including 1) knowledge, development, synthesis, and application; 2) focused inquiry resulting in higher-order learning; 3) applicable to real-world scenarios; dan 4) rich tasks. The characteristics support each other. The approach connects two or more disciplines (Y. Li et al., 2019). The indicators of the learning implementation stages by applying the STEM Approach in the core activity are: 1) using the learning approach based inquiry; 2) linking matter with daily life; 3) practicing; 4) involving students in practice; 5) students actively engaged in classroom practice; 6) guiding students in practice; 7) utilizing technology (computers, internet); 8) using active learning strategy; 9) communicating actively to students during learning; 10) giving tasks in groups; 11) using problem-solving learning method; 12) combining STEM in one subject (at least 2 STEM disciplines); 13) students motivated to like math; 14) developing teaching materials; 15) teaching according to the field; and 16) no gap between learners (Milaturrahmah et al., 2017).

Figure 1.1

Authentic Integration Module (Ramadhani et al., 2019)



1.9.3 Flipped Classroom Strategy

Flipped Classroom Strategy is implemented by transferring the direct learning process managed by the teacher in a big class to independent individual learning spaces using internet technology (Kim, 2018). The Module designs a learning condition where the learning is presented as homework outside the class using online video as media. Then, the valuable learning periods in class are managed to active learning activities (Shi et al., 2018). The Module explains informational technology literacy to the students; therefore, the learning activities become more independent and focused on high-order thinking skills. The class learning will focus more on problem-solving questions, discussion, and students' skill development for the 21st century. The students are required to be more active in learning independently. Before joining the class, they are expected to have prior knowledge about the material discussed in class. Teachers may become more creative since they are required to make learning media, such as tutorial videos, which can attract students' attention.

The first step in Flipped Classroom Strategy is dividing the learning material into two elements, comprising: 1) what will be discussed before entering the class, and 2) what will be discussed in the class (Yough et al., 2017). The learning employing this Module generally uses tutorial videos created by the teachers. They have to make attractive videos and help students achieve the learning objectives. The research conducted by Zainuddin & Perera (2018) presents six steps in implementing the Module; the three first steps involve online activities conducted outside the classroom, and the next steps are related to offline activities conducted at the class discussion. The online activities organized out of the class include: 1) the teacher shares videos, 2) the

students watch a video every week, and 3) the students conduct the online discussions. The online activities managed in the class comprise: 1) 40-minute listening exercise, 2) 45-minute conversation activities, and 3) 15-minute interactive feedback sessions (Zainuddin & Perera, 2018).

1.9.4 Comparing Routine Learning Module and Flipped Classroom Strategy Integrating STEM Approach

The Routine Learning Module in the Basic Concepts of Mathematics Course is implemented with the assistance of an e-learning system, comprising Shoology.com and Open Learning. The e-learning system used is still dominated by assigning and collecting assignments online. Explanations of mathematical concepts are given in class through face-to-face activities then the lecturer will give homework. The assignments are submitted via Schoology or Open Learning links. Unlike Routine Learning, the Flipped Classroom Strategy Integrating STEM Approach transfers the direct learning process by the teacher into an independent individual learning space facilitated by internet technology. Explanation of the concept is given as homework outside the classroom using online video media. Classroom learning focuses on active learning activities, High Order Thinking Skills, problem-solving, 21st century skill development, and encourages students to develop digital literacy skills.

The steps of learning activities are carried out in three stages, including preliminary activities, main activities, and closing activities (Shi et al., 2018). The following is a comparison of the implementation of Routine Learning Module and

Flipped Classroom Strategy Integrating STEM Approach, based on three stages of learning activities.

Table 1.1

Comparison of Routine Learning Module and Flipped Classroom Strategy Integrating STEM Approach

Learning Activities	**Routine Learning Module (**Problem Based Learning Module with Contextual Approach)	**Flipped Classroom Strategy Integrating STEM Approach**
	Preliminary Activities	
Motivation	Give learning motivation in contextual based on material benefits	Give learning motivation through critical thinking, creativity, digital literacy, and works
Apperception	Ask questions that connect prior knowledge to the material that will be to be studied	Students already have prior knowledge about the material through videos that have been distributed in the previous day and the lecturer asks questions related to problem-solving strategies
Conveying learning objectives	Learning objectives that will be conveyed are still dominated by Low Order Thinking Skill	Learning objectives that will be conveyed are dominated by High Order Thinking Skill
Conveying material coverage	The material coverage presented is dominated by cognitive abilities	The material coverage presented includes cognitive abilities and problem-solving abilities
	Main Activities	
	Students learn concepts and understand problems	Move the direct learning process from teachers in large groups into individual learning independently with the aid of internet technology.
	Students build work structures and determine problems	Learning is presented as homework outside the classroom using online video media.
	Students collect and share information	Students review the content at home and perform independent study activities.
	Students formulate solutions and determine the best solution	Valuable time in classroom learning is used for active learning activities.
	Students present solutions	Encourage students to improve information technology literacy. Focus on High Order Thinking Skill.

Learning Activities	Routine Learning Module (Problem Based Learning Module with Contextual Approach)	Flipped Classroom Strategy Integrating STEM Approach
		Classroom learning focuses on problem-solving strategies, discussions, and 21st century skills development. Find and discuss the obstacles experienced by students in solving problems.
Closing Activities		
Conclusion	Find direct or indirect benefits from learning outcomes.	Find direct or indirect benefits through critical thinking and problem-solving.
Feedback	Lecturers provide questions to test students' cognitive abilities.	Lecturers give HOTS questions to improve problem-solving skills.
Follow up	Give assignments (individual or group)	Provide project assignments related to the application of mathematics in daily life individually/in groups.
Activity plan for the upcoming meeting	Inform the lesson plan for the upcoming meeting.	Inform the material students need to study before the upcoming class through online videos, online discussions, and narrative PowerPoint. Students a mind mapping summary based on online video/narrative PPT.

1.10 Summary of Chapter 1

Mathematics has a significant role in advance a nation. Math concepts tended to be abstract; therefore, the teachers need to establish students' independent knowledge using an approach that connects science and technology. The development of science and technology which gets faster encourages teachers to adjust their skills to be following the occurring changes. Besides, the students are expected to be able to solve problems they encounter carefully, precisely, critically, and creatively. Using technology, teachers can deliver math more interactively and attractively. The students

can elaborate their insights anywhere and anytime with the help of the internet and gadgets.

The observational findings revealed numerous challenges in the teaching and learning of mathematics, particularly in the online classroom setting. Mathematics remains a formidable subject within the Primary Education Teaching Program. While students exhibited generally positive attitudes towards mathematics at a reasonably satisfactory level, there is room for improvement. Moreover, their proficiency in handling problem-solving questions was limited, particularly in analyzing story problems. The research findings indicated a positive correlation between an improved attitude towards mathematics and enhanced problem-solving skills, leading to improved learning outcomes. Challenges persist in the current landscape of online teaching and learning at universities, with potential causes including impractical learning Modules and underutilization of e-learning resources. Therefore, lecturers should consider implementing innovative learning Modules and optimizing the use of information technology to actively engage students in comprehending mathematical concepts.

STEM approach is an approach combining science, technology, techniques, and mathematics. The teachers can direct students to expand the concept comprehension to be able to combine theories and skills. With the approach implemented, the students can learn to think critically to cope with real-life problems. Science and technology have significant roles in developing science. The STEM approach is highly applicable to implement in the course of basic concepts of mathematics. With this approach, students can make efforts to learn the concepts precisely and connect them to problems

in daily life, especially those related to science and technology. The main focused skills in STEM are thinking critically, collaboration, communication, being creative, problem-solving, data literacy, digital literacy, and computer science.

One of the learning Modules suitable for online classes is Flipped Classroom Strategy. The teachers implement inverted teaching and learning where the activities managed in class at the previous traditional learning are conducted at home. In traditional classes, the teachers present material through lecturing, group discussion, reading, observing, and afterward, they give take-home assignments. On the other way round, in Flipped Classroom Strategy the students learn the material at home by watching videos, summarizing, making questions, having online discussions with classmates. They are required to see and review the learning contents before coming to the class. Next, they conduct discussion or practices at the class, but the activities merely function as strengthening or enrichment. The learning Module aims at establishing independent learning and critical thinking cultures. Flipped Classroom Strategy is a technology-based learning Module to increase students' engagement in the learning process and manage time to be more efficient.

The course of mathematics basic concepts is a necessary subject for primary prospective teachers. It is one of the mandatory subjects for PSTT students. Mathematicss has an important role in establishing critical and creative nation generations. PSTT students should master 21st-century skills to be able to teach following the class needs in the future. Therefore, their comprehension of mathematical basic concepts must be seriously considered. The field observations uncovered a misalignment between the mathematics concepts presented in teacher's books and those

in student's books. Upon course completion, students were anticipated to possess not only a grasp of the concepts but also the capability to articulate the benefits of learning mathematics. This, in turn, would foster positive attitudes towards mathematics among their own students.

The Primary School Teacher Training Program (PSTT) at UMS employed’an online-based learning system through platforms like schoology.com and Open Learning websites for the basic concepts of the mathematics course. Despite the extensive content available on these websites, the online learning process was not fully optimized. The previous learning Module failed to facilitate a deep understanding of concepts and lacked emphasis on enhancing problem-solving skills. Online learning primarily revolved around assignments, missing opportunities for comprehensive engagement. Various applications, such as narrated PowerPoint, OBS Studio, Camtasia, Screencast-o-Matic, and YouTube, were utilized for creating digital learning materials and tutorial videos. The aim was for lecturers to leverage these tools to elevate education quality and cultivate a competent generation capable of thriving in the technology-driven era. The proposed digital learning innovation in this research involved integrating the STEM approach with the Flipped Classroom Strategy.