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The Implementation of Flipped Learning Model and STEM Approach in Elementary Education: A Systematic Literature Review

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Abstract: This study aimed to explore the implementation and impact of the Flipped Learning Model (FLM) and STEM Approach in elementary education. The advancement of technology and the Covid-19 pandemic has increased the importance of e-learning, including in elementary schools. The literature review analyzed 193 academic works published in the past six years using NVivo, Mendeley, and VOSviewer software. The validity of the data was verified through the analysis of five online databases. The results showed that STEM research has been well-developed with innovative approaches that improve learning outcomes, while FLM research in elementary schools is limited. The study suggested that combining FLM with STEM Approach (FLM-SA) can optimize learning in the technological era. By integrating FLM-SA, students can engage in active learning experiences in class and acquire fundamental knowledge outside of class, offering a solution to e-learning challenges. The study emphasized the strong connection between FLM and STEM Approach and how they can support each other to enhance student learning.

Keywords: *Elementary education, e-learning, flipped learning, STEM, technology.*

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Introduction

Currently, education has shifted from being teacher-centered to student-centered. 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 situation, teachers must utilize innovative learning models to actively engage students in learning mathematical concepts. In order to develop students' skills in the 21st century, teachers need to combine science, technology, engineering, and mathematics (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. However, engineering and technology still faces several challenges, particularly in elementary education. To address this issue, it is essential to optimize the technological and engineering components of the science, technology, engineering, mathematics (STEM) approach through Flipped Learning.

The challenge faced with applying the STEM approach is that it requires many resources, media, and more time to collaborate in designing classroom learning (Wardani et al., 2021). 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

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literacy, digital literacy, and computer science (Vega et al., 2019).

STEM has a pattern referred to as the Engineering Design Process (EDP) or the procedure of designing a machine or work (Rodriguez & Shim, 2021; Schlegel et al., 2019). EDP has many versions that have been formulated by experts; however, in general, EDP has the following pattern: (a) define the problem, (b) plan solutions, (c) make a model, (d) test the model, and (e) reflect and redesign. Teachers have to take steps in the STEM approach: (a) identifying content standards, (b) identifying essential questions/driving questions, (c) establishing what the student knows and creating multiple and ongoing assessment opportunities, and (d) designing interdisciplinary learning activities (Wieselmann et al., 2020). Problems that occur in the real world are a perfect match for the problem-based learning approach, which is why the STEM approach is so effective (Sutaphan & Yuenyong, 2019). The EDP demands an adequate amount of time for students to attain the intended learning outcomes. However, the limited duration for learning poses a significant hurdle in achieving successful implementation of the EDP. To surmount this challenge, one of the viable solutions is to incorporate e-learning in the form of a flipped classroom model.

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. Students listen more to the teacher'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.

Several studies have proven that flipped learning has advantages to be applied to classroom learning (Hamid & Hadi, 2020; Zainuddin & Halili, 2016; Zainuddin et al., 2019). 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 Learning Model (FLM) has the potential to be applied in teaching and learning activities in higher education (R. Farida et al., 2019). The results revealed that the FLM 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 FLM (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).

It is important for elementary school students to be encouraged to think analytically and critically, as well as apply reasoning to solve problems (Ishartono et al., 2022; Nurdyansyah & Aini, 2017). This condition was caused by the learning process in the classroom that had not facilitated students to think HOTS (Badjeber & Purwaningrum, 2018; Purwasi & Fitiyana, 2020). The practice questions provided to students still incline to be LOTS (Koto et al., 2020; Saraswati & Agustika, 2020). Several challenges are encountered in the learning process in elementary schools. One such challenge is that students find it difficult to comprehend concepts due to the limited in-class learning time. Additionally, current e-learning practices tend to prioritize the provision and collection of assignments online, leading to a lack of active learning experiences. This has resulted in students relying more on memorization, particularly with regard to mathematical concepts, rather than understanding the underlying principles (Badjeber & Purwaningrum, 2018; D. A. Kurniawan et al., 2019; Purwasi & Fitiyana, 2020). The classroom instruction primarily emphasized the acquisition of subject matter knowledge, thereby restricting the time available for engaging in problem-solving activities. Additionally, the instructional approaches employed were comparatively limited in their scope and variety.

With the advent of the Covid-19 pandemic, many countries have been promoting online learning in elementary education. This shift has prompted elementary schools to focus on enhancing the quality of e-learning. Nevertheless, the implementation of e-learning has encountered several obstacles, which have prevented its optimal operation (Mustakim, 2020; Pangondian et al., 2019; Sagita & Khairunnisa, 2019). E-learning-based learning media was still minimal, tended to be monotonous, and only employed simple Powerpoints (F. Farida et al., 2019; Suryawan & Permana, 2020). The combination of science, technology, engineering, and mathematics in learning is still low (Rahmadhani & Wahyuni, 2018; Santoso & Mosik, 2019; Simatupang et al., 2019). It is because teachers had not mastered the steps for implementing STEM properly (Nurhikmayati, 2019; Sutrisno & Hamdu, 2020). Moreover, the lack of technical proficiency among Elementary School teachers in utilizing Information and Communication Technology (ICT) as an instructional medium remains a challenge (Kadarisma & Ahmadi, 2019; Rahim et al., 2019).

The implementation of the FLM integrated with the STEM Approach could potentially enhance students' participation in both synchronous and asynchronous discussions, and promote self-directed learning (Burke & Fedorek, 2017; R. Farida et al., 2019; Holmlund et al., 2018; Milaturrahmah et al., 2017; Parra-González et al., 2020). This approach can foster students' technological literacy, making the learning experience more interactive and engaging. Furthermore, the flipped classroom model provides teachers with more opportunities to solicit students' perspectives, challenges, and difficulties in understanding the concepts. Teachers can integrate ICT into their instruction to provide students with high-quality e-learning experiences and to foster students' digital literacy. This model also allows teachers to allocate more time in class for active learning experiences, instead of delivering direct instruction as in the traditional learning model. Several studies have explored the integration of STEM and Flipped Learning in Elementary Education (Aidinopoulou & Sampson, 2017; Bond, 2020; González-Gómez et al., 2016; Weinhandl et al., 2020). After reviewing the findings of these studies, it was decided to undertake a review of the present study. The research problem addressed through this literature review is how to integrate the FLM with the STEM approach to optimize e-learning in the current technological era. Upon conducting the review, it was discovered that there is a lack of literature addressing the question of how to effectively combine the STEM Approach with the FLM in elementary education. Therefore, the purpose of this study was to review previous research on the application of STEM and FLM in Elementary Education, with the aim of identifying strategies for combining the two approaches. To achieve this, the Prisma Model is applied to identify relevant articles for review. The results of the analysis through the Prisma Model were used to answer the six Mapping Questions (MQs) and one research question (RQ).

Methodology

The objective of a systematic literature review (SLR) is to identify, evaluate, and interpret diverse research results pertinent to the research question, theme, or phenomenon of interest (Bond, 2020; Kitchenham, 2004). The SLR process consists of three stages: review planning, review execution, and report writing (Arici et al., 2019; Zhu, 2021). By employing SLR, mapping can be applied systematically in accordance with these three stages (Lo et al., 2017; Petersen et al., 2015). A SLR and a Systematic Mapping on how the FLM with STEM Approach in Elementary Education has been implemented are employed as research methods. The phases utilized are the PRISMA flowchart and recommendations (Galindo-Dominguez, 2021; Moher et al., 2009; Zhu, 2021).

A literature review on Flipped Learning in elementary education, Flipped Learning in primary education, FLMs, STEM in elementary education, STEM in Primary Education, and STEM-Flipped Learning comprised the data analysis procedure. The steps applied in data analysis were: (a) systematic review of other SLRs; (b) definition of research questions for the SLR and mapping; (c) definition of inclusion and exclusion criteria; (d) definition of search strategy; (e) definition of quality criteria; (f) data extraction; (g) results; and (h) data analysis and report writing.

Identifying the Need for a Review

Before deciding to conduct an SLR or literature mapping, it is necessary to determine whether this study is truly necessary. It must first be determined whether a literature review already exists that addresses the posed research questions. A previously conducted systematic review or mapping cannot be repeated unless there was a bias in the previous review or there have been new scientific and technological developments and research since the previous review (Altemueller & Lindquist, 2017; Aydin et al., 2021; Petticrew & Roberts, 2006). To obtain information, whether a systematic review and mapping has been published that answers the research question studied, it is necessary to conduct a search on previously published systematic reviews and mappings. Are there SLRs or mappings that have been published and provide answers to the research question posed?

Five online databases, namely Scopus, ScienceDirect, JSTOR, ProQuest, and Springer, were searched. These databases were chosen because they offer global coverage, a large database of articles, high-quality indexing of articles, and easy access to search for scientific articles. Flipped Learning in Elementary Education, Flipped Learning in Primary Education, FLM, STEM in Elementary Education, STEM in Primary Education, and Flipped Learning-STEM in Elementary Education are the keywords that were used in the search. On the basis of search results with similar terms, 259 documents were identified in Scopus; 638 documents were identified in ScienceDirect; 268 documents were identified in JSTOR; 2320 documents were identified in ProQuest; and 439 documents were identified in Springer. On the basis of the article's title, keywords, and abstract, the suitability of the article with the formulation of the research problem was determined based on the database data obtained during the identification phase. At this stage, 608 documents related to reviews and mappings were obtained from five databases.

Based on the results of the review of the five previously mentioned databases, it can be concluded that no previous studies answered the research question posed in this study. This is because STEM and Flipped Learning have different research foci (Birgili et al., 2021; Kozikoğlu, 2019; Yangari & Inga, 2021; Zheng et al., 2020), and there is no research examining how to combine the STEM approach and FLM in elementary education.

Research Questions

After determining the actual needs for SLRs in this study, the next step was to formulate the research and mapping questions. Initially, the research question (RQ) was:

How is the FLM with STEM Approach (FLM-SA) applied in Elementary Education?

Meanwhile, the six Mapping Questions (MQs) posed were:

MQ 1: How many articles have been published by each database regarding the implementation of STEM and FLM in Elementary Education?

MQ2: What key words are used in the published articles about the implementation of STEM and FLM in Elementary Education?

MQ3: How are the studies distributed by year?

MQ4: What methodologies are used in the published research articles about STEM and FLM in Elementary Education?

MQ5: In which countries are studies on the implementation of STEM and FLM in Elementary Education conducted?

MQ6: With which population are the studies conducted?

Data Mining

The metadata of scientific publications were obtained through online database searches that generated CSV-formatted data. The filtered research articles are then analyzed and sorted using the applications Nvivo and Mendeley to ensure that there are no duplicate article titles. All of the authors in this article participated in the phases of defining the protocol, searching, and extracting the initial data from the databases. Current search results are as of October 12, 2022. Peer Review is utilized to manually filter articles from databases by all authors. The mining of data is accomplished through an iterative and incremental procedure. Each process consisted of distinct phases. The PRISMA diagram of the study is shown in Figure 1.

In the initial phase, article identification results were obtained by searching five selected databases from 2016 to 2021. The displayed database results were then downloaded as CSV files. The collected data was then organized using Google Sheets spreadsheets, Mendeley application, VOSviewer, and NVivo application. These applications automatically check the obtained collection of article titles for duplicates and delete them if any are found. The next step, following the elimination of duplicates, is the extraction of data using a variety of filters.

In the second phase, the items collected in the first phase were transferred to the third sheet. The inclusion and exclusion criteria were applied on the third sheet. To advance to the next phase, each publication must satisfy all inclusion criteria.

During the first phase, 3,316 items were deleted, and between the first and second phases, 114 items were eliminated. After meeting the inclusion criteria, 209 articles were eliminated, leaving 285 articles for the quality criteria process. The following are the criteria for exclusion: (a) The research has no relation to STEM education in Elementary or Primary Education; (b) The research is unrelated to Flipped Learning in Elementary Education or Primary Education; (c) The study addressed STEM Approach, but not in the context of education; (d) The research examined Flipped Learning, but not in the context of education; (e) The published article is neither the result of research nor a review of the relevant literature; (f) Article is not written in English; and (g) Publication articles are neither freely accessible nor available via subscription through the databases of Universitas Muhammadiyah Surakarta or University Pendidikan Sultan Idris.

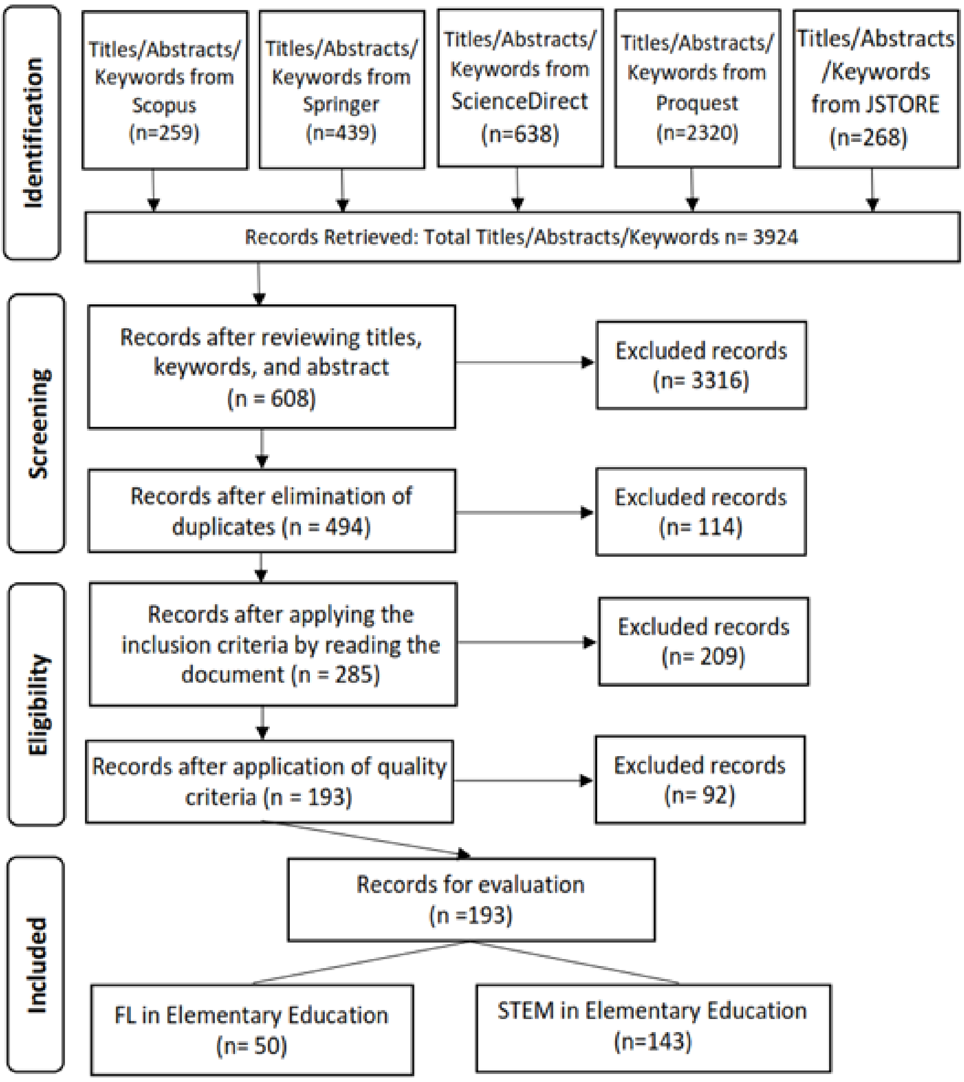

Figure 1. The PRISMA Diagram of the SLR

The focus of the third stage, literature review, is publication feasibility. The articles obtained in the second phase are then reread. The objective of the third reading stage is to answer questions based on the problem formulation. The following quality criteria are utilized: (a) Not clearly aligned with flipped learning in elementary education or primary education; (b) The publication's purpose is not clearly aligned with STEM implementation in elementary or primary education; (c) Some studies do not propose an appealing qualitative, quantitative, or mixed methodological approach; (d) Some studies disregard the limitations encountered during the research process; and (e) At least one of the two systematic literature review research questions was not addressed.

After the third stage was completed, 193 articles qualified for the evaluation phase. There are 50 articles about the FLM in elementary education, while there are 143 articles about STEM in elementary education. Each article is meticulously analyzed in order to respond to research and mapping questions. The data analysis was conducted using version NVivo software version 12.

Results

The following are the outcomes of the analysis of the systematic mapping question:

MQ 1: How Many Articles Has Each Database Published on STEM and FLM Implementation in Elementary Education?

After conducting the identification, screening, and eligibility phases, a total of 50 articles pertaining to the FLM in elementary education and 143 articles on STEM education in the elementary level were obtained. Figure 2 illustrates the number of indexed articles found in the Scopus, Springer, ScienceDirect, ProQuest, and JSTOR databases.

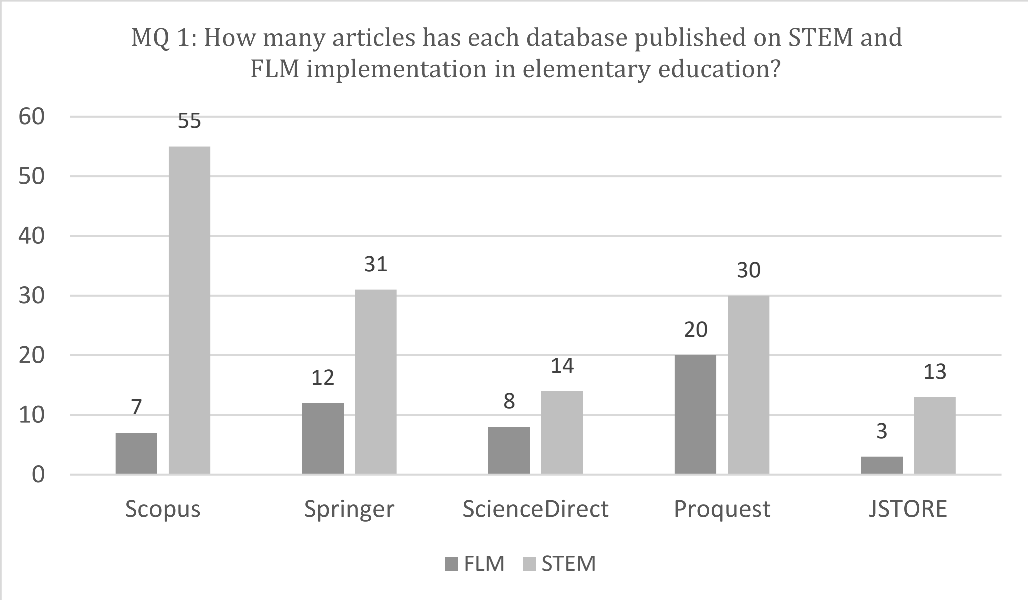

Figure 2. Results to the MQ1

MQ2: What Are the Search Terms Employed in Articles That Have Been Published on the Utilization of STEM and FLM in Elementary Education?

According to the analysis presented in Table 1, the keywords that appear most frequently are: (a) STEM Education; (b) Flipped Classroom Model; (c) elementary education; (d) primary education; (e) science education; (f) ICT; (g) mathematics; (h) active methodologies, learning, scientific method; (i) primary school, and (j) pre-service primary teachers.

Table 1. Results to the MQ2 / Top 10 Popular Keywords

Elementary Education and Primary Education			
STEM		**FLM**	
Quantity	**Keywords**	**Quantity**	**Keywords**
99	STEM education	51	Flipped Classroom Model
49	elementary education	17	ICT
23	primary education	11	active methodologies, learning, scientific method
13	science education	10	primary school
11	mathematics	8	preservice teacher, contextual game-based learning
10	pre-service primary teachers	7	Teaching/learning strategies
6	mathematics education	6	motivation, social sciences teaching
5	educational robotics, programming, technology enhanced learning	5	blended classroom, educational innovation, higher education, self-regulated learning, co-regulation and shared regulation, STEM, teacher education
4	curriculum development, educational video game, engineering education, engineering education, self-efficacy, solar system, creativity	4	context-based learning technology, e-learning, mathematics education, sustainability
3	active learning, attitude towards science, attitude towards mathematics, augmented reality, engineering design, inquiry-based teaching, professional development, robotics, science education, teacher professional development, teacher training.	3	improving classroom teaching, learning achievement, meta-analysis, pedagogical change/ issue, professional activity/ teachers', professional development
2	3D printing, academic achievement, attitude scale, attitudes, etc (http://bit.ly/mq2result)	2	academic improvements, applications in subject areas, attitudes, co-creation, collaborative/cooperative learning, creative thinking, etc (http://bit.ly/mq2result)
1	active learning, advantages of teaching applications, agent-based simulation, agricultural literacy, andragogy, etc (http://bit.ly/mq2result)	1	added value of technology, asynchronous learning, authentic context, authentic learning, barriers, etc (http://bit.ly/mq2result)

MQ3: How Are the Researches on STEM Approach and FLM Distributed by Year?

According to Figures 3 and 4, the highest number of articles on STEM and FLM in Elementary Education were published in 2020 and 2021. In 2021, there were 39 articles published on STEM, whereas in 2020, the number was 29. The number of STEM articles decreased in the previous years, with 23 articles in 2019, 24 articles in 2018, 17 articles in 2017, and 11 articles in 2016. Similarly, the number of FLM articles in 2021 was 14, whereas in 2020, the number was 15. The number of FLM articles decreased in previous years, with 9 articles in 2019, 2 articles in 2018, 7 articles in 2017, and 3 articles in 2016.

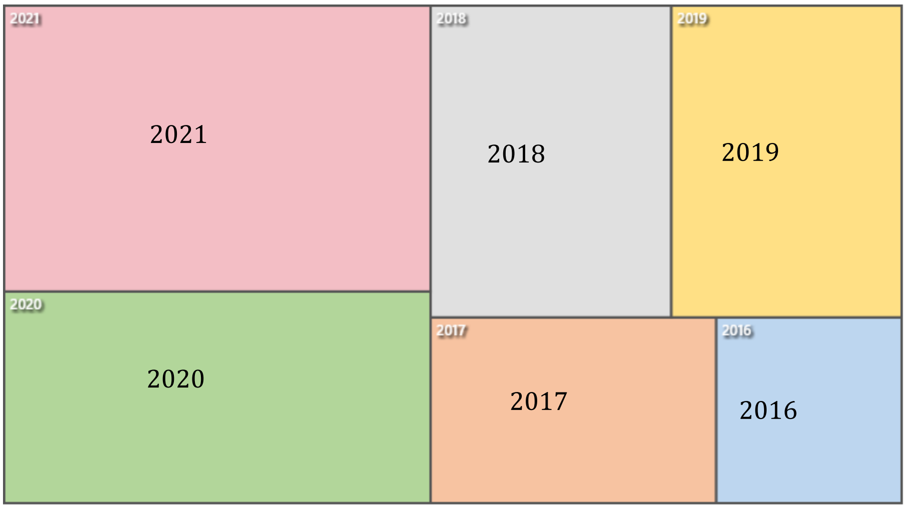

Figure 3. Tree Map Regarding STEM in Elementary Education Distributed by Year

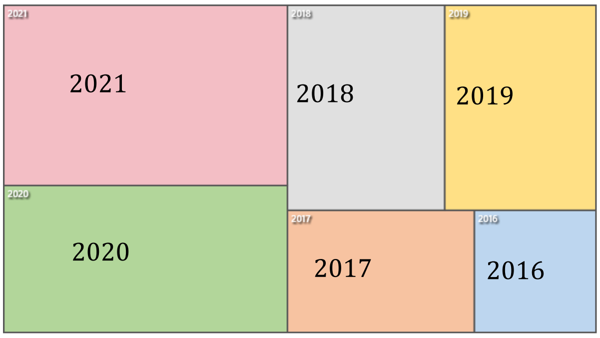

Figure 4. Tree Map Regarding FLM in Elementary Education Distributed by Year

MQ4: What Methodologies Are Used in Research Publication Articles on STEM and FLM in Elementary Education?

As demonstrated in Figure 5, Experimental Research is the most commonly employed method for researching STEM and FLM. Additionally, various other methods such as Qualitative Research, Literature Reviews, Case Studies, Quantitative Research, Mixed Methods Research, Critical Review Essays, Research and Development, Surveys, and Action Research are also utilized.

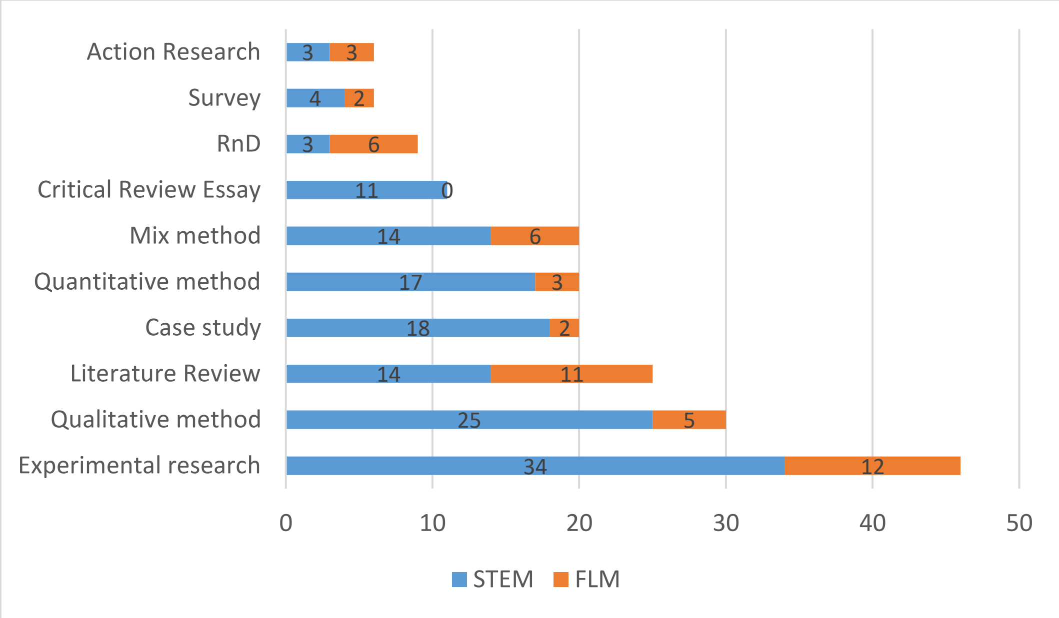

Figure 5. Types of Research Methods Used in STEM and FLM in Elementary Education

MQ5: In Which Countries Are Studies on the Implementation of STEM and FLM in Elementary Education Conducted?

Research on STEM and FLM in Elementary Education has been conducted on four continents, including North America, Europe, Asia, and Australia. As shown in Table 2, STEM research in Elementary Education has been conducted by scholars from 30 countries, with the United States leading the way with 50 studies. Spain follows with 23 studies, while Greece and Indonesia both have 8 studies. Turkey has 7 studies, and Hong Kong and Australia both have 6 studies. Ireland has 5 studies, China has 4 studies, and the Netherlands and Thailand both have 3 studies. Brazil, Finland, Korea, and Portugal each have 2 studies.

Table 2. Countries Where Its Researchers Are Recorded Researching STEM in Elementary Education

Country (Continent)	**Quantity**	**Country (Continent)**	**Quantity**
USA (America)	50	Bahrain (Asia)	1
Spain (Europe)	23	Canada (America)	1
Greece (Europe)	8	Chile (America)	1
Indonesia (Asia)	8	Cyprus (Europe)	1
Turkey (Europe)	7	Egypt (Africa)	1
Hong Kong (Asia)	6	France (Europe)	1
Australia (Australia)	6	Germany (Europe)	1
Ireland (Europe)	5	India (Asia)	1
China (Asia)	4	Israel (Europe)	1
Netherlands (Europe)	3	Lebanon (Asia)	1
Thailand (Asia)	3	Malaysia (Asia)	1
Brazil (America)	2	Peru (America)	1
Finland (Europe)	2	Phillippines (Asia)	1
Korean (Asia)	2	Sweden (Europe)	1
Portugal (Europe)	2	Vietnam (Asia)	1

Table 3 shows that research on the FLM in Elementary Education has been conducted in 18 nations. Spain leads with 14 studies, followed by Turkey with 8 studies. The USA has 5 studies, while China has 4 studies. Hong Kong and Greece both have 3 studies, and Ecuador has 2 studies.

Table 3. Countries Where Its Researchers Are Recorded Researching FLM in Elementary Education

Country (Continent)	Quantity	Country (Continent)	Quantity
Spain (Europe)	14	Cyprus (Europe)	1
Turkey (Europe)	8	Israel (Europe)	1
USA (America)	5	Latvia (Europe)	1
China (Asia)	4	New Zealand (Australia)	1
Hong Kong (Asia)	3	Russia (Europe)	1
Greece (Europe)	3	Serbia (Europe)	1
Ecuador (America)	2	Taiwan (Asia)	1
Australia (Australia)	1	Ukraina (Europe)	1
Austria (Europe)	1	United Kingdom (Europe)	1

MQ6: What Data Population Did the Study Utilize?

As demonstrated by Figure 6, a significant proportion of the conducted research in STEM and FLM in Elementary Education pertains to elementary school students, pre-service teachers, and teachers. The research literature encompasses 60 articles on STEM and 12 articles on FLM involving elementary school students. On the other hand, the number of articles on STEM and FLM involving elementary pre-service teachers is 23 and 22, respectively. However, to date, no research has been conducted in FLM that involves elementary school teachers. This disparity in the number of studies between STEM and FLM may be attributed to the relative scarcity of FLM applications in Elementary School education compared to the increasingly popular adoption of STEM approaches. The latter is driven by the numerous benefits it offers in facilitating 21st-century learning processes.

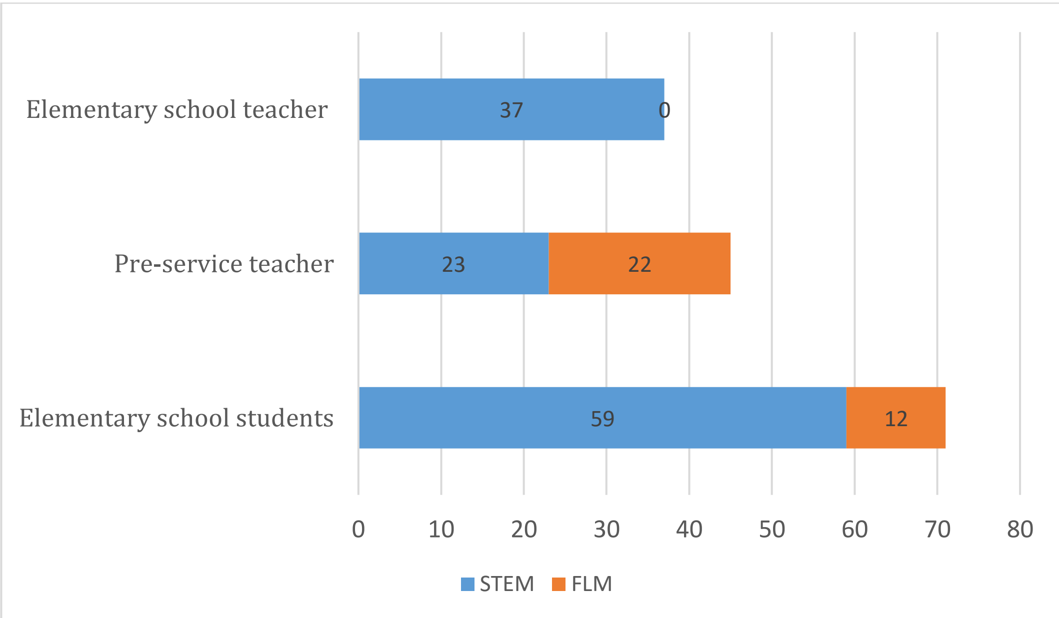

Figure 6. Distribution of Research's Population and Sample

According to Figure 7, there is an unequal distribution of involvement across the six level from Year 1 to Year 6. Specifically, grades 1 to 3 have a lower frequency of implementation of the STEM approach. Additionally, grades 1 to 3 have not yet fully utilized technological resources, resulting in a limited number of studies implementing Flipped Learning in these grades. However, there is potential for Flipped Learning to be integrated in Elementary Schools. The advancements in technology and the rise of e-learning in developed nations have prompted both educators and researchers to explore the implementation of Flipped Learning in Elementary Schools. The continued progression of digital technology and its application in education will lead to a more advanced and innovative learning experience in all grade levels within Elementary Schools. The sample population of FLM research in Elementary School consists of grade 3 (6%), grade 4 (31%), grade 5 (18%), and grade 6 (44%).

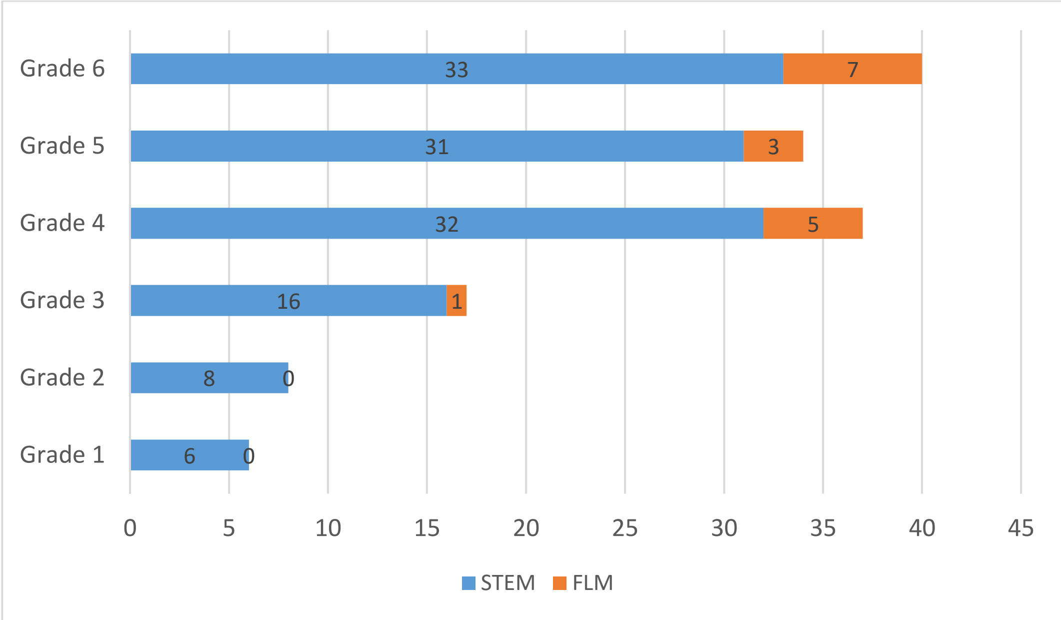

Figure 7. Distribution of Sample and Population Based on Year Level in Elementary School.

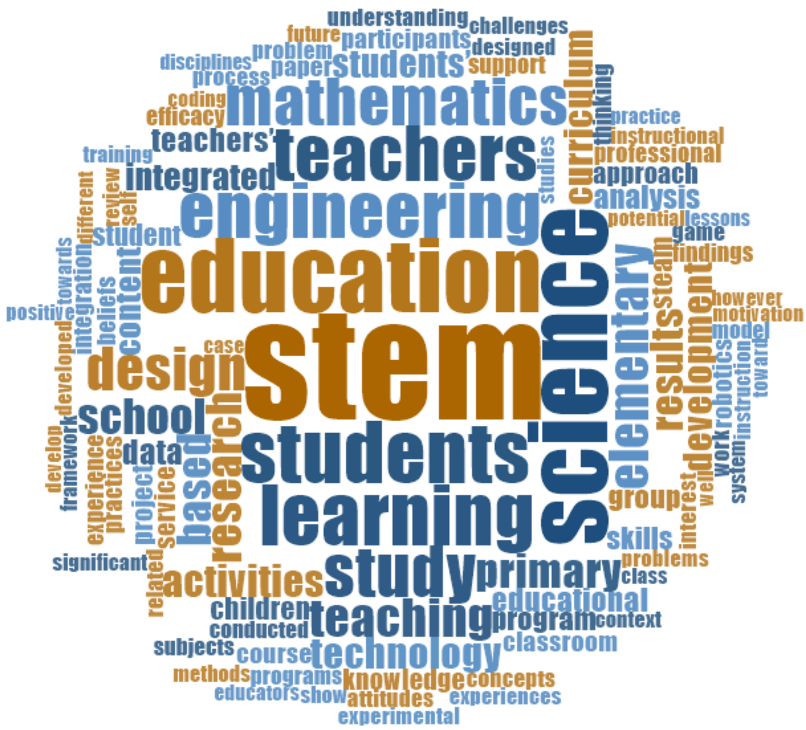

Figure 8. Word Cloud of STEM in Elementary Education (Based on Abstract Analysis)

Figure 9. Word Cloud of FLM in Elementary Education (Based on Abstract Analysis)

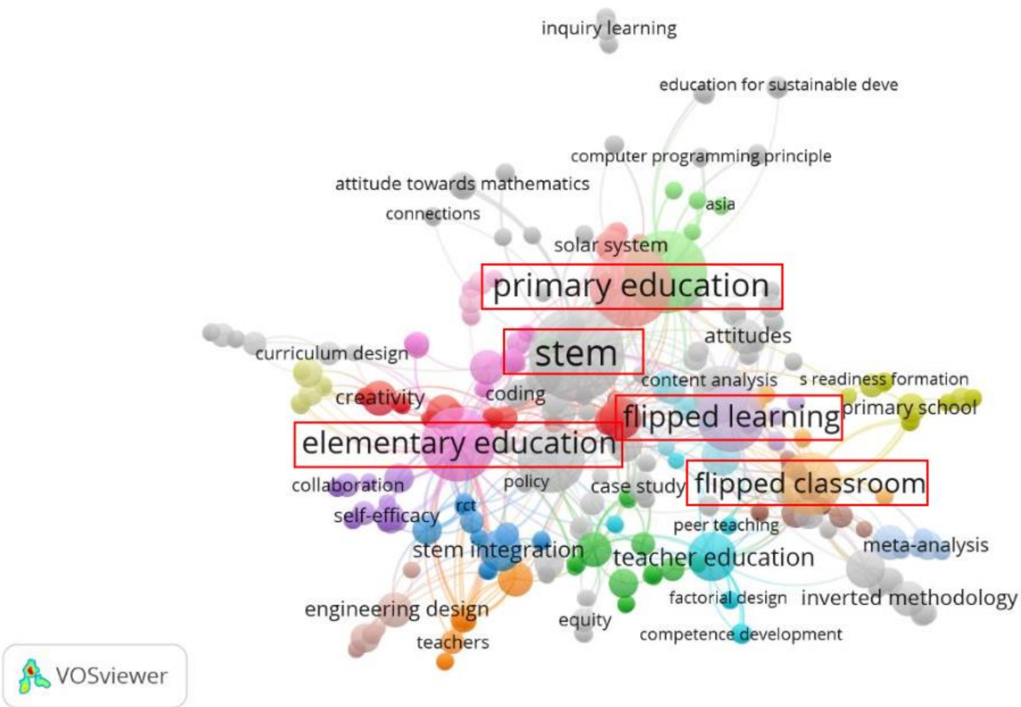

Figure 10. Vosviewer Cluster Graphic of Keyword Result: Minimum Number of Keyword Occurrence Is 1

The recent studies in STEM and FLM in Elementary Education/Primary Education, as evidenced by the abstract analysis (Figure 8 and 9) keyword analysis using VOSviewer (Figure 10), have demonstrated a greater focus on STEM than Flipped Learning. While research on STEM and FLM is still primarily conducted in higher education institutions for aspiring Elementary School teachers, the number of studies involving students from Elementary Schools in the implementation of STEM and FLM remains low. To address this imbalance, future research endeavors should aim to explore the integration of technology in education through STEM and Flipped Learning in Elementary Schools.

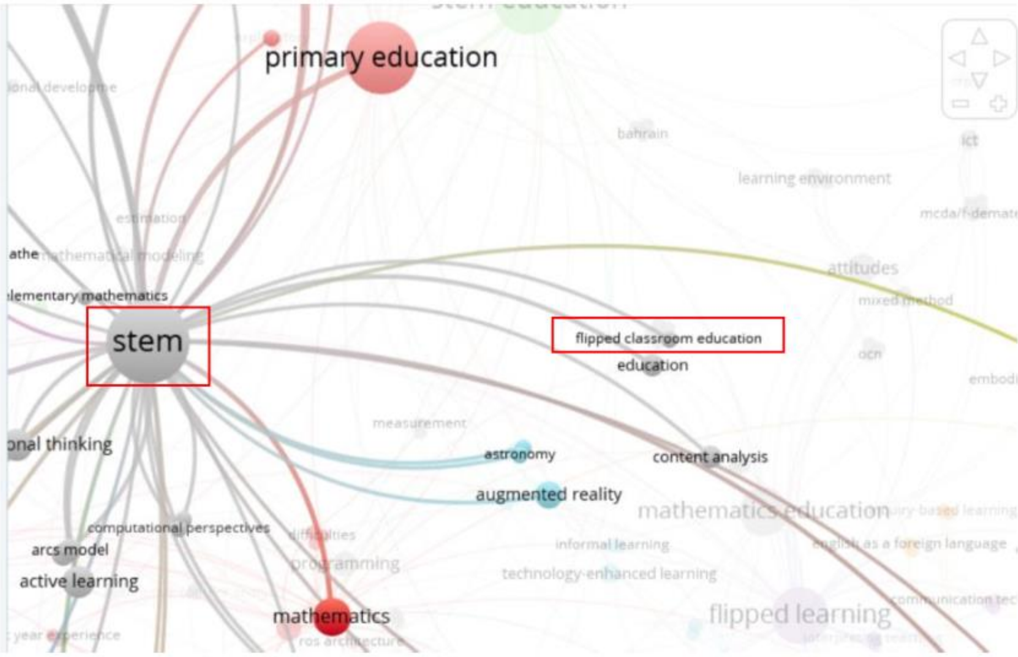

Figure 11. Vosviewer Cluster Graphic of Keyword Result: The Links Highlighted When the Word 'STEM' Is Highlighted

The Figure 11 depicts the prevalence of research conducted on STEM education in the realm of elementary and primary education over the past five years. This research has often explored the interconnections between STEM and various elements such as primary education, elementary education, computational thinking, active learning, teacher professional development, augmented reality, and educational robotics, among others. However, a less explored area in this regard is the relationship between STEM and Flipped Learning. Based on the Figure 12, research on the FLM has primarily been linked with pre-service teachers. There remains limited research that applies the FLM in elementary schools.

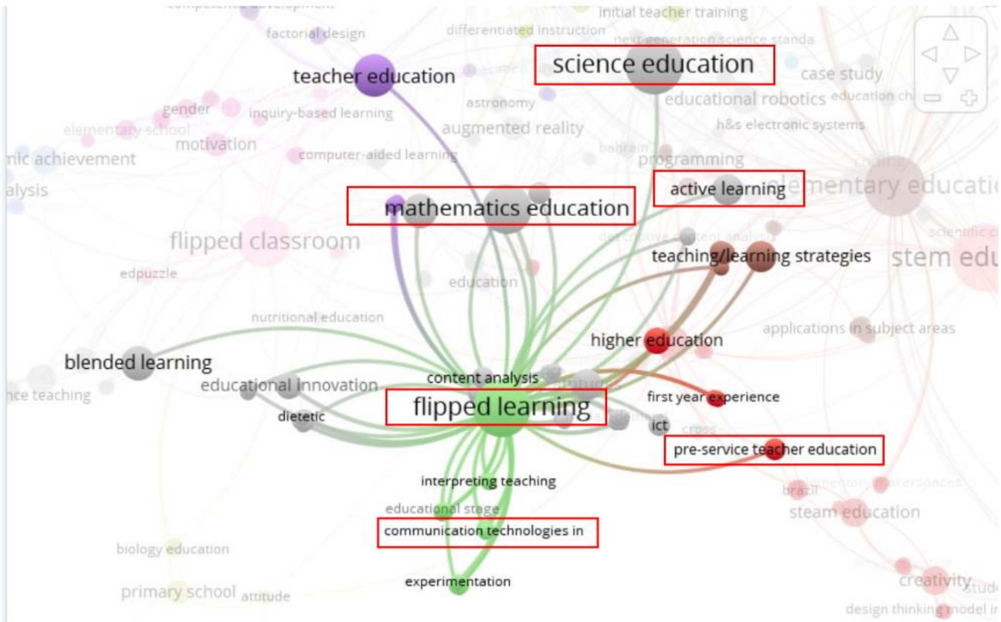

Figure 12. Vosviewer Cluster Graphic of Keyword Result: The Links Highlighted When the Word 'Flipped Learning' Is Highlighted

Discussion

A qualitative analysis was carried out on the eligible papers selected through a stringent eligibility evaluation process. This analysis aimed to address one research questions central to the Systematic Literature Review (SLR). The question concerned the methodology of implementing the FLM integrated with the STEM Approach (SA) in Elementary Education. The challenges that must be faced in implementing the innovative learning model in Elementary Schools are the need for information and resources, internet infrastructure, and technological equipment (Çil, 2021). The FLM is often associated with the use of ICT/technology, blended learning, active learning, mathematics, science, etc. From the analysis, it can be concluded that Flipped Learning has a connection with STEM. The factor that has not yet been present in previous FL research is the aspect of engineering. By linking FL and STEM, learning can facilitate students to learn more optimally.

The challenges encountered in implementing STEM include the aspect of engineering and technology which is not yet optimal. This challenge can be overcome through the implementation of the FLM. This can be estimated from previous research that stated that the FLM can enhance a teacher's ability to utilize technology (Arici et al., 2019; Hall et al., 2020). Additionally, the FLM transforms the learning process by providing explanations through videos prior to in-class activities. Some applications that have been used to develop videos in Flipped Learning research include: Educreations, GoClass, Techsmith, Nearpod, PowToon platform, eduCanon, PowerPoint presentation using Screenflow software application, and Doceri (Altemueller & Lindquist, 2017; Botella et al., 2021; González-Gómez et al., 2016; Jeong et al., 2016). Thus, in-class activities can be meaningfully used to teach students in developing skills. If students have more time to hone their skills, the engineering aspect in STEM will be carried out more effectively.

FLM in Elementary Education

The implementation of e-learning or blended learning in educational settings often employs the use of Learning Management Systems (LMS), such as Schoology, Moodle, Edmodo, Edpuzzle, Open Learning, Google Classroom, among others (Altemueller & Lindquist, 2017; Bond, 2020; Botella et al., 2021; Jeong et al., 2016). A prevalent issue encountered in such classes is that the utilization of e-learning systems is primarily limited to the distribution and collection of assignments online (Galindo-Dominguez, 2021; Núñez et al., 2020). Conventional face-to-face activities are utilized to provide explanations of concepts during class, followed by homework assignments that are submitted through the online platform. Unlike Routine Learning, the FLM transfers the direct learning process by the teacher into an independent individual learning space facilitated by internet technology (Arici et al., 2019; Graziano, 2017; Kale, 2018). 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 (Chaipidech et al., 2021; González-Gómez et al., 2016; Graziano, 2017).

The implementation of learning activities is comprised of three distinct stages, including preliminary activities, main activities, and closing activities (Shi et al., 2018). The implementation of FLM with STEM Approach based on the three stages of learning activities, is derived from a comprehensive analysis of previous research on FLM and STEM Approach in Elementary Education (Botella et al., 2021; Çil, 2021; González-Gómez et al., 2016; Jeong et al., 2016; Lo et al., 2017; Luo et al., 2020; Núñez et al., 2020; Zhu, 2021). The implementation steps is shown in detail in table 4.

Table 4. The Steps of Implementing FLM With STEM Approach

Learning Activities	FLM with STEM Approach
Preliminary Activities	
Motivation	Give learning motivation through critical thinking, creativity, digital literacy, and works
Apperception	Students already have prior knowledge about the material through videos that have been distributed in the previous day and the teacher asks questions related to problem-solving strategies
Conveying learning objectives	Learning objectives that will be conveyed are dominated by High Order Thinking Skill
Conveying material coverage	The material coverage presented includes cognitive abilities and problem-solving abilities
Main Activities	
Move the direct learning process from teachers in large groups into individual learning independently with the aid of internet technology.	
Learning is presented as homework outside the classroom using online video media.	
Students review the content at home and perform independent study activities.	
Valuable time in classroom learning is used for active learning activities.	
Encourage students to improve information technology literacy.	
Focus on High Order Thinking Skill.	
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 through critical thinking and problem-solving.
Feedback	Teachers give HOTS questions to improve problem-solving skills.
Follow up	Provide project assignments related to the application of mathematics in daily life individually/in groups.
Activity 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 create a mind mapping summary based on online video/narrative PPT.

How to Apply FLM With STEM Approach Assisted by LMS

FLM (FLM) is an instructional model in which students learn basic subject matter knowledge before in-class meetings, then come to the classroom for active learning experiences (Gómez-García et al., 2020). The fundamental subject matter is delivered through instructional videos and accessed by students through online classes. The subject matter is delivered first, while the classroom is used as a place to answer questions. In this learning model, students solve problems, engage in discussions, navigate challenging scenarios, continuously monitor their progress, learn in groups, and engage in higher-order thinking. Previous research has identified various Learning Management Systems (LMS) that are suitable for implementing the Flipped Learning Methodology (FLM), including Edmodo, Schoology, Edpuzzle, BlackBoard, Google Classroom, and Moodle (Altemueller & Lindquist, 2017; Bārdule, 2021; Bond, 2020; Botella et al., 2021; Jeong et al., 2016). As for synchronous learning, it can be facilitated through the use of Zoom video conferencing technology. This platform provides two-way communication during lessons, allowing for visual engagement through the use of a digital camera, audio interaction via microphone and headphones, and the sharing of presentations and collaborative work through screen sharing capabilities.

FLM is a form of blended learning. The subject matter is delivered first, while the classroom is used as a place to answer questions. For the FLM to be implemented optimally, teachers need to pay attention to the principles. The five principles of the FLM are: 1) problem-centered principle, 2) activation principle, 3) demonstration principle, 4) application principle, 5) integration principle. These principles were later developed into an FLM design, namely: 1) pre-class video lectures; 2) pre-class online exercises; 3) in-class warm-up exercises and a brief review; 4) in-class mini-lectures; 5) in-class small-group problem-solving. The first step toward effective flipped learning in an online course is to decouple the learning process from time/space coordinates.

The principle of FLM learning will be carried out through several learning steps. The steps of the FLM are divided into three stages, namely: 1) Before class (outside the classroom), 2) Inside the classroom, 3) After class (outside the classroom). The learning activities in the first stage (Before class) are: 1) students recall relevant prerequisite knowledge using instructional videos (activation principle); 2) students learn new basic knowledge with relevant examples through instructional videos (demonstration principle), 3) students do online exercises. Learning activities in the second stage (Inside the classroom) are: 1) students are given real-world problems (problem-centered); 2) teacher help students recall pre-class materials by offering a short quiz and review (activation); 3) teacher demonstrate the skills needed to solve the problems and present advanced material during class (demonstration); 4) students solve the basic problem and problem-solving exercises (application); 5) students work collaboratively by discussing problem-solving ideas, explaining steps, and confirming answers; 6) conclusion and delivery of after class assignments. Activities in the third stage (After class) are: 1) students work on problem-solving exercises provided in online classes; 2) the teacher evaluates students learning outcomes. Teachers should build interactivity into the videos, which can be done in a variety of ways. Teachers could have students take notes on the video, have them respond to an online forum, or use some other creative strategy. The theoretical framework in combining both of the FLM and STEM is depicted in Figure 13.

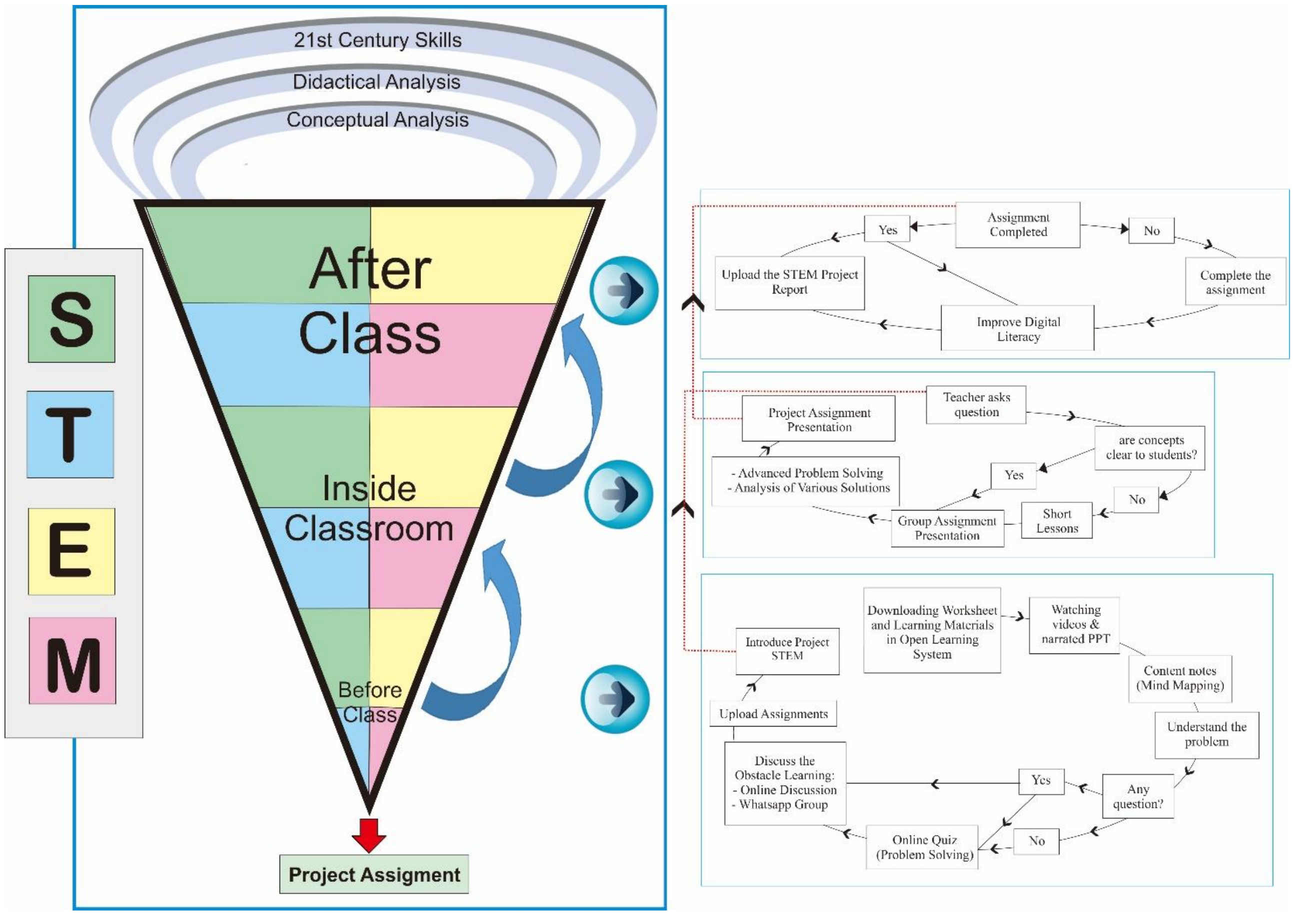

Figure 13. The Theoretical Framework of FLM With STEM Approach

Learning activities that apply the STEM Approach can be carried out through 9 stages of teaching, namely: (a) Identification of social issues, (b) Identification of potential solutions, (c) need for knowledge, (d) decision-making, (e) development of prototype or product, (f) test and evaluation of the solution, (g) socialization and completion of the decision stage, (h) give comments and discussion, and (i) conclusion. STEM integrates all four disciplines cohesively. Science is used to find out and explain the concept of life and also scientific phenomena around us. Technology is used to build, enhance and improve nature efficiently. Engineering is used to maintain, modify, or design materials, processes, and systems. Mathematics represents facts, phenomena, and further understanding of nature through numbers.

Conclusion

This systematic review analyzed the utilization of the FLM and STEM Approach in Elementary Education over the past 6 years, encompassing elementary school students, elementary pre-service teachers, and elementary school teachers as the study population. Results from the Mapping Questions analysis indicated the presence of STEM and FLM in Elementary Education studies in five databases, including Scopus, ScienceDirect, JSTOR, ProQuest, and Springer. Despite extensive research on STEM and its positive impact on learning outcomes, there is limited research on FLM, especially for elementary school students. The number of studies in this field increased from 2016 to 2021, showcasing growing interest from the academic community in learning innovations such as STEM and FLM. The USA and Spain are among the leading countries in conducting research on STEM in Elementary Education, while Spain and Turkey have carried out the most research on FLM in Elementary Education. The majority of research on STEM and FLM has been focused on higher grades (years 4, 5, and 6), highlighting the need for further development of FLM with the STEM Approach in lower grades (years 1, 2, and 3). Additionally, research involving elementary school teachers in flipped learning remains limited, emphasizing the need for government support and training for elementary school teachers to enhance their skills in implementing the FLM. These findings can provide a basis for future research in implementing the FLM in Elementary Schools.

The current study found the strong linkages between STEM and FLM, and how they can be leveraged in maximizing the learning process in the technology-driven era of the 21st century. The results from a keyword analysis utilizing the VOSViewer application revealed that elementary schools have significant potential for the implementation of STEM and FLM. Consequently, the authors compiled a framework for integrating STEM and FLM in elementary education based on previous research outcomes. The proposed FLM comprises three stages: a) Before class (outside the classroom), b) Inside the classroom, c) After class (outside the classroom). For optimal learning outcomes, it is essential to fully integrate STEM aspects into the FLM steps, including the integration of project assignments, a hallmark of the STEM Approach. Furthermore, it is critical to identify and understand the obstacles in implementing the FLM-STEM Approach (FLM-SA) to ensure effective implementation. Based on previous research, various strategies can be employed to overcome these obstacles.

Recommendations

Further research is recommended to use technology and e-learning, particularly in elementary schools, by providing insights into innovative learning models, internet-based applications, and Learning Management Systems. Future research could explore the development of FLM-STEM Approach models and investigate the impact of FLM-SA on student learning outcomes in elementary schools. Practitioners can benefit from several important recommendations to enhance the effectiveness of FLM implementation. These recommendations include: (a) Improving the skills of primary school teachers in creating pre-class learning videos that are engaging and attractive to students. (b) Providing clear and comprehensive explanations of the purpose and nature of the FLM from the outset to ensure effective learning. (c) Offering regular reminders to students to develop discipline and time management skills to complete their pre-class self-study assignments. (d) Establishing active communication with parents can significantly contribute to providing effective learning support for students during the self-learning stage at home.

Limitations

This literature review is limited by the scope of published articles from 2016 to 2021 and a focus on learning in elementary schools. Future research may consider expanding the range of years studied in the literature review and examining other levels of education as well

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Availability of data and materials

This is a systematic review of previous literature. All the articles reviewed in this study are available in the Scopus, ScienceDirect, JSTOR, ProQuest, and Springer databases. In addition, for the validity of the conclusions, the data extraction process has been described step by step and documented by means of different spreadsheets which are available at https://bit.ly/SLRFLMSADATA

Confict of interest

The authors have no relevant financial or non-financial interests to disclose.

Authorship Contribution Statement

Rusnilawati: Conceptualization, design, analysis, writing, securing funding, final approval. Rahaimah Binti Ali: Data analysis, reviewing, supervision, final approval. Hanapi: data interpretation, critical reviewing. Sutama: Critical revision of manuscript, technical support. Rahman: Drafting manuscript, admin, technical support

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