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Flipped Learning in Mathematics Classroom: A Systematic Literature Review

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Abstract

Flipped learning has become increasingly popular in improving student's achievement in mathematics. Flipped learning in a mathematics classroom is learning by doing thorough assessments out of the classroom or in the school. This research systematically reviewed the existing studies published between 2012 to 2023 (n=15). The finding of this study suggests that flipped learning is always effective for achievement, and involves discussion, self-learning, engagent, motivation, peer collaboration, and instructor feedback. FL approach provided better learning outcomes than the conventional approach. But, there are many challenges; such as; technological issues, lack of internet access, IT resources, and skills of FL. Thus, this review has recommended proposing a new model for effective flipped learning in the mathematics classroom.

Keywords: achievement, effect, flipped learning, mathematics classroom, engagement.

Introduction

According to the National Education Policy 2076, there supposed to be an improvement in the education quality through integrated technology and promoting innovative teaching methods. New teaching strategies are needed to enhance their knowledge and address challenges related to quality,

standard equity, and access(Sheikh, 2017). The flipped learning model helps students acquire a deeper understanding of mathematical concepts in which students engage actively in learning (Tucker, 2012). A novel approach to teaching and learning is developed using video as a pre-class learning exercise called flipped learning. The term 'flipped learning' refers to an educational approach with two components: interactive group learning activities performed inside the classroom and technology-based instruction outside of the school(Bergmann & Sams, 2012; Bishop & Verleger, 2013). Flipped learning involves assigning content instruction at home or any other place in pre-class but in the conventional teaching mathematics a homework is assigned after the class. These methodological differences make flipped classroom method identical from the traditional approaches to teaching mathematics and effective in terms of improvement in student achievements (Wei et al., 2020). Students' attitudes toward mathematics, prior knowledge, peer interaction, the school environment, traditional teaching approaches, and self-learning all influence their achievement in mathematics (Joshi, 2019). Mathematics learning difficulties can be caused by several factors, including anxiety and monotonous ways of teaching mathematics (Acharya, 2017). One of the most important strategies of the flipped classroom model is the ability for students to obtain quick guidance and feedback from their teachers.

Mathematics achievement was poor because almost all of the teachers adopted traditional lecturing techniques in the classroom(National Council of Mathematics Teachers, 2000). The issues of poor engagement and interest among students in mathematics classes persist in FL(Boaler et al., 2019). Flipped learning is a new method of education that was created because of the deficiencies of the conventional technique,

Flipped learning helps students solve problems in mathematics by engaging online resources to independently study mathematical ideas, hence creating motivation for the required knowledge(Bishop & Verleger, 2013). Flipping the conventional environment for learning, flipped learning has become an effective pedagogical approach that challenges the conventional classroom(Bergmann & Sams, 2012; Tucker, 2012). In the flipped learning approach, students watch videos or online reading materials to get pre-knowledge of the subject matter outside of class and then engage in problem-

solving exercises, collaborative work, and discussions during class time. The Indian educational system has to adopt innovative and novel approaches at all educational levels, from basic to higher education, to become more effective and pertinent globally (Sheikh, 2017).

In my observation, I identified several issues with teaching mathematics, which I have categorized into three categories: worldwide problems, difficulties in Asian nations, and local problems. These problems arise from a lack of conventional approaches, equality and access, interaction application in real life, self-directed learning, cooperation, group discussion, individual learning, etc. Innovative teaching methods include student-focused instruction, active learning, flipped learning, and critical and creative thinking activities (Naccarato & Karakok, 2015).

Flipped learning is a new paradigm that has helped motivate students, encouraging self-learning, engagement, and collaboration in mathematics. The use of digital technology and virtual manipulatives in flipped mathematics classrooms enhances student engagement and improves conceptual understanding (Loizou, 2019).

Flipped learning activities take place outside of the classroom and are brought inside the classroom. Utilizing technology like internet networks and multimedia learning materials has made it possible to apply the flipped teaching approach in appropriate situations.

Gathering the learning requirements of every student is one of the topics that teachers should naturally have a thorough solution. Teachers can help all learners even in huge courses with a variety of learners, standards, and time bounds. The flipped classroom strategy, which influences technology to its advantage, provides a solution to this question.

Today's world views education and its impact on students' conduct and education as one of the most important concerns confronting mankind, to the point that many developed nations have built their policies.

Many students in Nepal obtain scores that are below the national average, which emphasizes the need for innovative learning to address these problems. The empirical studies and my teaching experiences have motivated me to study and explore the application of flipped learning in mathematics classrooms.

The purpose of this systematic literature review is to investigate the use and

efficacy of flipped learning in the context of mathematics education.Furthermore; it explores the opportunities of flipped learning in mathematics and the challengesof using flipped learning in the teaching of mathematics. This study has tried to answer the question; what is flipped learning in mathematics classrooms? How has flipped learning supposedly affected students' interest in mathematics? What typical challenges do teachers encounter when integrating flipped learning into mathematics classes? Which best practices are offered for implementing flipped learning in mathematics classes effectively?

Methodology

This study is based on an empirical relevant literature review of different educational databases including ERIC, Google Scholar, Pro-Quest, PubMed com, Science direct.com, Jstor.com, nepjol.com, eric.ed.gov. This review has searched by using the keywords 'flipped learning', 'mathematics classroom', 'student's engagement', 'motivation', and 'performance. Empirical Studies that presented actual data, published between 2012 and 2023, that specifically studied the flipped classroom paradigm in mathematics teaching fulfilled the selection criteria. It has takendata with limited to the articles (n=15) published in electronic databases.To confirm and validate the main ideas and data presented during the literature review, the initial draft of this paper was uploaded in a Google Doc.

The results show the fifteen article titles that were considered to be relevant to the keywords. The systematic research review was limited to publications that were published between 2012 and 2023. A survey of the literature review on flipped learning for mathematics classrooms is the foundation of this work. The literature review begins with a discussion of the chosen comparative studies of flipped learning in the mathematics classroom after the researcher discusses the findings related to objectives and research questions.

Results and Discussion

There are 15 studies related to flipped learning in mathematics classrooms. From the review of fifteen studies, I have found themes of a comprehensive review of research based on objectives and research questions. Findings are related to opportunities and challenges of flipped learning in mathematics classrooms.

Table 1.
Descriptions of the main components of the 15 studies reviewed

Authors (Year)	Setting country Subject area	Focus	Theoretical Underpinning	Methods	Outcomes
Bergmann, Jonathan Sams, Aaron (2012)	Flipped learning	Before you flip, consider this model			Effectiveness of flipped learning
J Bishop, MA Verlege(2013)	Flipped Classroom	Advances in technology and ideology have unlocked entirely new directions for education research	Constructivism	Survey	Students tend to prefer video lectures but prefer interactive classroom activities over lectures. Anecdotal evidence suggests Student learning isimproved for the flipped compared to traditional classroom.
CR Clark,2015	USA The Effects of the FLM	The Effects of the Flipped Model of Instruction on Student Engagement and Performance	Cognitive	Mixed method	The flipped model of instruction has an increase in student engagement and performance.
Naccarato, Karakot,2015	South Africa flipped classroom model in undergraduate	Expectations and implementations of the flipped	Cognitive	Qualitative	Conceptual knowledge, or delivery of prerequisite skills

	mathematics courses	classroom model			before new concepts, viewed this model as an opportunity to improve students' higher order
FerhatKardes, BinnurYesilYaprak,2015	Turkey A Current Approach To Education: FLM	the emergence and development of the model will be described		Systematic Review	Flipped Learning Approach has been applied in different settings and their effectiveness in different fields of education
FezileOzdamli, Gulsum Asiksoy,2016	Nicosia, Cyprus. Flipped classroom approach	its potential in the education field and to make it recognized more by educators and researchers		Systematic Review	The positive development in desire, interest, and motivation of educators using technological equipment will be effective in spreading this approach.
E.M. Marshall, D.A. Wilson, V.E. Mann(2016)	UK Attitudes and anxiousness about maths	To investigate attitudes and anxiousness about maths.	Constructivism Theory	Quantitative	the flipped learning approach and creation of formative online tests are quite a time

					consuming, the benefits to the students
Kaushal Kumar Bhagat, Cheng-Nan Chang and ChunYen Chang,2016	China the effectiveness of the flipped classroom learning environment on learner's learning achievement and motivation	the effects of flipped classrooms on learners with different achievement levels in learning mathematics concepts	cognitive theory of multimedia learning (CTML)	quasi-experimental design	a significant difference in the learning achievement and motivation between the two groups with students performing better using the flipped classroom
RamaKrishnan J. JohnsiPriya ,2016	India the flipped classroom has positively affected the IX std. Students' achievement in mathematics.	Effectiveness of flipped classroom in mathematics Teaching		Experimental	The Flipped Classroom module on Area and Perimeter in Mathematics has affected the students' achievement in Mathematics
Cassondra Leo, 2017	South Carolina Flipped Classroom Pedagogical Model and Middle-Level Mathematics Achievement	the relationship between a flipped classroom pedagogy and student achievement. The participant-researcher aim	Constructivism Theory	Action research Design	opportunities within the school district for new mathematics teachers utilizing the flipped classroom approach.
Yanghui Shi, Yangiong, Ma, Jason Maclead, and	Flipped classroom instruction	effectiveness of flipped model		Systematic Review	helps college students

Harrison Hao Yang(2020)		classroom instruction		Meta-analysis	to improve their cognitive learning across, a wide-reaching synthesis of currently available interdisciplinary research reports
BengiBirgili, FatmaNevraSeggie, EbruOğuz (2021)	Beijing Normal University Trends of Flipped Learning	trends and outcomes of flipped learning research	Cognitive	Mixed method	an increase in student performance and positive influence on cognitive, affective, and soft skills.
Rachel V Staddon,2022	A supported FLM	A new 'supported' FLM for teaching maths was implemented.		Systematic Research	Students on a wide variety of degree tracks are positive about the flipped model. The supported flipped model is considered superior to traditional teaching methods.
Monalisa Dash (n.d)	India	Exploring the Effectiveness of Flipped Learning on Mathematical	Bloom's Taxonomy	Mixed method	Flipped Learning technique has improved Triarchic Abilities namely. Mathematical

		Triarchic Abilities			Practical ability, Mathematical Analytical Ability, and Mathematical Creative Ability in Secondary School
Nicole Angelo M, 2023	Philippines	Effectiveness of Flipped Classroom Approach to the Performance of Students in Mathematics 10		Quasi-Experiment method	learnershave prior knowledge using a video lecture,to improve their mathematical and logical skills. recommended using this strategy to enhancestudents' mathematical ability and logical skills.

From the above literature matrix, the flipped learning for this review has been discussed in many themes.

Advantages of Flipped Learning in Mathematics Class

Improvement of Instructor-Student Interaction. A good education involves the delivery of instructions with relevant material, but, time-bounded teacher-student discussion, interaction, and engagement. Teachers may provide instructions and information outside of class using flipped classrooms, which have more time for discussion and interaction in the classroom (Bergmann & Sams, 2012; Bishop & Verleger, 2013; Clark et al., 2022; Shi et al., 2020) and question answer and interactive(Staddon, 2022) solving complex problems(Leo, 2017) help of teachers and peers by group discussion, and collaborative class (Bhagat et al., 2016) educators can identify students who need more support through interactive discussions. They can take proactive steps to satisfy their requirements and promote active learning with the students(Clark et al., 2022).To benefit from flipped learning, students must be fluent in the fundamental material before to class, and they must perform advanced learning activities in class. The purpose of

active, learner-centered learning activities in the classroom is to improve students' engagement in challenging class discussions and to foster interactive, peer and instructor learning.

Self-Paced Learning. The flipped classroom method focuses on this approach what, when, and how teachers teach students and employ a digital platform outside of the classroom to increase student, engagement and create self-learning space(Clark et al., 2022; Johnson, 2012; Lai & Hwang, 2016; Shi et al., 2020). Through the use of pre-lesson materials provided by the teacher, such as video clips and web-based instructions, students learn by remembering and comprehending(Fung et al., 2021). This approach is known as the "flipped classroom" concept. Through, the interaction between instructor -students, and peers, discussion, problem-solving, project learning, and classroom engagement, students also gain innovative thinking skills including applying, analyzing, creating, and evaluating.

Students' Motivation and Engagement. Flipped learning helps to decrease students' mathematical anxiety and boredom and provides students with significantflexibility. The results of flipped learning suggest improved academic achievement as well as positive impacts on the achievement of individual learning and cognitive skills(Bishop & Verleger, 2013; Naccarato & Karakok, 2015; Ozdamli & Asiksoy, 2016).Flipped learning is an educational strategy for motivation and effective achievement in mathematics learning (Chen et al., 2014; Omotayo & Adeleke, 2017; Shi et al., 2020).One of the primary benefits of using pre-recorded instructional videos is that instructors aren't worried about having to make up for missing content because students may access the lectures and important information on the videos at any time and from any location(Bergmann & Sams, 2012).Using technology to transfer the lecture outside of the classroom and learning activities to provide individuals with homework and exercises with concepts(Wei et al., 2020). The relatively new flipped classroom method of instruction aims to improve student engagement and performance (Bergmann &Sams, 2012). Flipped learning is an educational strategy for motivation and effective achievement in mathematics learning (Omotayo&Adeleke, 2017).

Improved learning and motivation. The preparedness of students to learn is an essential component of any educational scheme's effectiveness. Motivated to learn, incentives, giveaways, and encouragement must be

provided for learning to be actively sought out(Boaler et al., 2019). For learning to be successful, motivation and its existence in students must thus be continually upheld in the design of educational programs(Bhagat et al., 2016). According to reviewed studies, several factors, such as the adoption of innovative teaching strategies, the creation of an original performance evaluation system, the provision of essential supplies and equipment in classrooms, and the development and enhancement of the learning environment, all influence students' motivation for successful learning.

The advantages of the flipped learning method are to use of digital platforms and pre- to student engagement and learning. It focuses on discussion, problem-solving, project learning, and classroom engagement. This approach is particularly effective in mathematics, as it reduces mathematical anxiety and boredom, provides flexibility, and improves academic achievement. The flipped classroom method improves students' learning and cognitive skills in mathematics.

Challenges of Flipped Learning Classroom

In the review of flipped learning, I found students faced many problems implementing the flipped learning strategies. There was a technological problem (Basal, 2015; Chen et al., 2014; Clark et al., 2022). Most participants had their own mobile devices but they did not have enough internet access at home (Bergmann &Sams, 2012; Birgili et al., 2021; Ozdamli&Asiksoy, 2016). Some students are unable to load and play the videos at home (Merrill, 2015; Qaisar et al., 2019). There were problems with the IT resources of students and teacher preparation of flipped classrooms (Bhagat et al., 2016; Milman, 2012; Staddon, 2022). There is no difference in student achievement between flipped learning and conventional methods (Clark et al., 2022). Flipped classrooms face challenges like technological issues, internet access issues, and resource limitations, but students' achievement remains consistent with conventional methods. Although, FL is an effective strategy in teaching learning.

Findings of the Study

In a flipped classroom, the usual order of learning and application shifts, with students acquiring the essential knowledge outside of class and instructors helping them clarify and apply that knowledge in class through active, interactive learning. This method encourages teachers to fulfil their most crucial responsibility, which is to guide their students to higher levels of use

and deeper thought as the top courses have always done. A flipped instruction is centered on the needs of the students.

Meaningful and impactful learning is the goal of the flipped learning approach. According to the review, this approach improves student success and the effectiveness of teaching mathematics in the classroom. This learning approach uses technology as a pedagogical tool to improve the learning process. With a focus on self-paced learning, this approach gave students the chance to prepare for class and work through problems with the support of peers and teachers. This learning helps teachers support students' development by keeping an eye on their academic achievement and managing their study habits. Once this is accomplished, pupils will no longer experience forgetting and will in its place learn. Flipped learning is high-level, focused learning that arises outside of the classroom. Tasks are completed in the classroom. This function gives the instructor the chance to keep an eye on student work and manage as well as some obstacles in teaching and learning. In the flipped classroom, students are required to examine and analyze materials outside of class using self-directed learning strategies, and then actively apply what they have learned in a group setting within the classroom. Although flipping has the potential to assist students in achieving significant learning objectives, it is only one of several educational tools that teachers may use to help students use class time more effectively.

Conclusion

By reversing the traditional learning environment, flipped learning has become a popular instructional strategy. This approach focuses on having students watch videos or read materials outside of class to familiarize themselves with the content, allowing in-class time to be used for problem-solving exercises, collaborative tasks, and discussions. Various motivational strategies, such as online assessments, group problem-solving exercises, and video lectures, are used to implement flipped learning in mathematics.

This comprehensive review of research examines the effectiveness of flipped learning in mathematics education, particularly its impact on learning achievement, instructional methods, and student engagement. Overall, this systematic review enhances understanding of the flipped classroom model in mathematics education, offering insights into its effectiveness as a pedagogical tool that promotes deeper conceptual understanding and active learning.In contrast to conventional lecture-based formats, flipped learning

increases student engagement through active participation in problem-solving and interactions through class.From the literature review, the researcher found many advantages of using flipped learning strategies. They are improvement of instructor-student interaction, encouraging self-paced, teacher professional development, student engagement, self-learning, motivation, student motivation, and engagement in mathematics learning. Flipped strategies for student feedback include creating novel tasks, providing deeper reading assignments, encouraging unofficial study groups, and creating a peer under graduate study program. These methods help students apply their knowledge, deepen their understanding, and organize weekly meetings for further practice.

While teacher-centered learning and direct instruction are part of the out-of-class teaching component, learner-centered learning theories and interactive activities are part of the in-class teaching component. In response to the aforementioned difficulties, the flipped classroom moves lectures outside of the classroom and uses class time to enhance student comprehension and assign learning tasks for a better comprehension of the course themes and problem-solving. Additionally, learner-centered activities that involve problem-solving, cooperative learning, active learning, peer learning, and collaborative learning align with the theoretical foundations of the flipped classroom.The challenges of flipped learning in mathematics classrooms were technological issues, video loading, and playback difficulties, IT resource issues, and teacher preparation for flipped classrooms are insufficient skill. Literature showed that there is no significant difference in student achievement between flipped and conventional learning methods. Common features were the 15 review papers that variations in the technology devices used in evaluations of student learning outcomes, and teaching methods. Results of the review show the flipped classroom model's benefits for increasing student engagement, improving their conceptual understanding of mathematical ideas, and refining existing problem-solving techniques. This review has recommended proposing a new model for effective flipped learning in the mathematics classroom.

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