Improving Secondary School Mathematics Teachers' Effective Lesson Implementation through Lesson Study

Temesgen Yadeta Dibaba
Jimma University, Ethiopia

Abbi Lemma Wedajo
Jimma University, Ethiopia

Faith Maina
Texas Tech University, USA

Adula Bekele Hunde
University of Oslo, Norway

Abstract

The main purpose of this study was to explore how engaging in lesson study improves secondary mathematics teachers' effective lesson implementation to support students' learning better. The research was conducted in Jimma City, Ethiopia, and employed design-based research with qualitative data collected from two secondary schools and 12 mathematics teachers. A purposive sampling technique was used to select participants. Interviews, observations, and document analysis were the main sources of data. The data were analyzed thematically supported by Atlas-ti qualitative data analysis software. Findings indicated that engaging in lesson study improved mathematics teachers' effective lesson implementation. LS improved participants' practice of lesson presentation, use of diverse student-centered teaching methods, assessment, behavior management, instructional aids, time management, and feedback strategies. School leaders' positive attitudes and teachers' commitment were found to be supportive, while shortage of time and teachers' high teaching load were constraints. It would be vital to integrate lesson study into teachers' school-based professional development programs to improve mathematics teachers' effective lesson implementation in the study setting. The study suggests further investigation in more secondary schools by incorporating quantitative evidence with larger a sample size.

Keywords: effective lesson implementation, lesson study, mathematics teachers, professional development, secondary school

In the ever-changing educational environment, teachers are encouraged to implement lessons effectively in their day-to-day teaching. Effective lesson implementation plays a central role in students' success in school and in their lives (Matić et al., 2020). The conception of effective lesson implementation considerably varies, largely dependent on the educational traditions in different countries (Matić et al., 2020) and is controversial because it involves a range of factors (teacher, learning environment, and students) that collectively work (Rahaman, 2018). However, some authors describe the concept of effective lesson implementation as the knowledge, skills, strategies, behaviors, and processes which lead to improved student learning outcomes (Hidayati et al., 2021). Effective lesson implementation is also viewed as teachers' ability to make a positive impact on a student's life, and academic career and empowering them to reach their full potential (Matić et al., 2020).

Further, effective lesson implementation is described as teachers' pedagogical practices of solving problems occurring in real instructional situations by applying knowledge, ability, skills, and experiences creatively to achieve the desired results (Rahaman, 2018). The emphasis is on teachers' practices to explore the hidden capacities of the students and shape their behavior in a desirable direction (Hidayati et al., 2021). Pertinent to this study, thus, effective lesson implementation is conceptualized as secondary school mathematics teachers' appropriate use of pedagogical elements involved in their teaching practices (learning objectives, content, teaching methods, learning materials, time, assessment, classroom management, and feedback strategies) to promote students' mathematics learning. Effective mathematics lesson implementation (EMLI) creates mathematical potential among the learner in terms of knowledge, attitudes, skills, and logical thinking (Matić et al., 2020). This means, teaching mathematics can be deemed effective when it positively impacts students' learning and results in the realization of the stated learning objectives (Hidayati et al., 2021). This conceptualization of EMLI is, used to guide this study.

In the context of Ethiopia, mathematics education is considered fundamental for science, and technology studies (Seifu, 2019). Hence, EMLI is emphasized to develop students' understanding of mathematical concepts, problem-solving, logical reasoning, critical thinking, creativity, abstract thought, and analysis (Sebsibe et al., 2023). While EMLI is recognized as a key factor in improving student's learning outcomes, it has remained a challenging situation in secondary schools in Ethiopia (Sebsibe et al., 2023; Tefera et al, 2018). In the country, a series of research findings in science and mathematics subjects indicated low students learning outcomes in grade 10 and 12 national examinations (Sebsibe et al., 2023; Tefera et al, 2018). Among the explanatory reasons were teachers' deficient classroom practices, and inadequate teaching skills and techniques (Sebsibe et al., 2023). Most teachers were unable to implement learner-centered lessons, inadequately used teaching and learning resources, and assessment techniques, and rarely provided feedback on classroom activities to enhance students' learning and progress (Sebsibe et al., 2023). Most students also think that mathematics is a difficult subject that requires them to have high critical thinking ability (Seifu, 2019). Thus, many students struggle with mathematics and become dissatisfied as they continually confront obstacles to engagement (Seifu, 2019). Practical actions taken to solve the problem appear very limited. Tackling the problem at the school level through research-informed intervention has

been less substantial. As a result, the issue of secondary school teachers' EMLI is one of the crucial areas to be focused on to bridge the current practice gaps teachers have. This initiated study focused on improving secondary school mathematics teachers' effective lesson implementation through lesson study (LS) based intervention to support students' mathematics learning. LS, originated in Japan has gained wide reputations in improving mathematics teachers' effective lesson implementation (Adler et al., 2023; Alamri, 2020; Roorda et al., 2024). Therefore, the main purpose of the study was to explore how engaging secondary school mathematics teacher in LS improves their effective lesson implementation in Jimma, Ethiopia. To achieve this purpose, the study is guided by the following research questions.

1) How does engaging in LS improve secondary school mathematics teachers' effective lesson implementation?
2) What are the school context-related factors that support and/or hinder the success of LS to improve secondary school mathematics teachers' effective lesson implementation?

Theoretical-Conceptual Frameworks

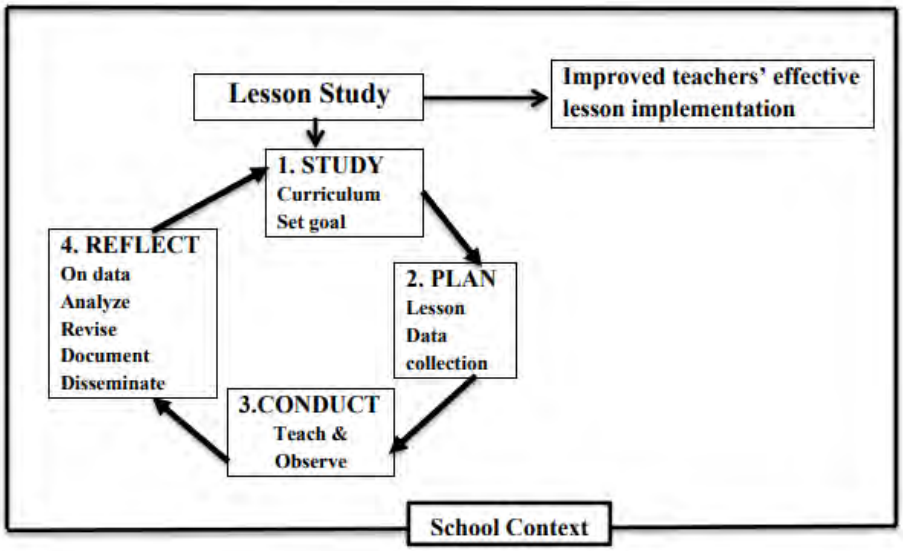
Social constructivism provides a framework for the use of LS to improve teachers' EMLI. Social constructivism emphasizes a learner-centered and active role of learners in the learning process to create knowledge for themselves (Akpan, 2020). LS enable teachers to place students learning at the center of their learning (Lewis et al., 2019). Constructivist maintains the gradual process of rethinking what is taught, how it is taught, and how learning is assessed collaboratively in a specific context (Rock et al., 2005). LS provides multiple opportunities for teachers to reflect, discuss, analyze, evaluate, and share understandings with other teachers on their practice (Lewis et al., 2019). Constructivist supports contextualized approach to teaching (Thi Thu & Thi Thu, 2023). LS is a context-based model, where learning is promoted via real-world context (Widjaja et al., 2017). Finally, constructivism stresses learning is best achieved through authentic and meaningful tasks that challenge and motivate learners (Thi Thu & Thi Thu, 2023). LS provides teachers with the opportunities to identify problems that challenge the students and solve students' learning challenges (Lewis et al., 2019). Thus, it is logical that building teachers' EMLI practices through LS is considered in light of constructivism theory.

Social learning theory (SLT) from the perspective of professional learning through observation and participation also provides a base for understanding the role of LS in improving teachers' EMLI practices. The SLT focused on observational learning and the mental modeling of observed behaviors provides an opportunity for teachers to (re)construct behaviors to implement in the classroom (Watson, 2013). As teachers observe largely more experienced colleagues, they construct this, knowing that it represents a safe and stable practice (Watson, 2013). LS represents a strong relationship between practice and teachers' needs (Mhakure, 2019). This provides opportunity for mathematics teachers to collaboratively engage in LS processes essential to improve EMLI (Lomibao, 2016). This allows mathematics teachers with an opportunity to collaboratively plan lessons and practice them to address students' learning difficulties (Hidayati et al., 2021). LS establishes a link between teachers' teaching practice

and the learning process using real classroom situations as experimental activities. Thus, teachers become lifelong learners seeking to improve their pedagogical skills, and EMLI (Ogegbo et al., 2019). In addition, this study used a conceptual model depicting the impact of LS on teachers' EMLI shown in Figure 1.

Figure 1

Conceptual Model Informing the Study



This conceptual model shows the four stages of lesson study (Study-Plan-Conduct-Reflect) that work in cyclical iterative manners to improve teachers' effective lesson implementation. At stage 1, the LS team studies curriculum materials that provide a rationale for pedagogical decisions, choices, and information on student thinking. Then, the team identifies the learning goal in terms of students' learning of a topic. At stage 2, the study teams collaboratively plan a research lesson – a real lesson designed, taught, and observed. At stage 3, the collaboratively planned lesson can be taught by one of the members of the team. The other team members observe students learning and collect data. At stage 4 team members gather for a post-lesson reflection and discussion during which they share the collected data, discuss implications, examine evidence, and reflect on the experience, especially concerning the learning goals of the lesson and the research theme. Further, LS is a school-based teachers' professional development model in the school context. Thus, the school contexts play a vital role in supporting and/or hindering its effective LS practices and, consequently teachers' effective lesson implementation.

Literature Review

In recent years, one of the keys to educational innovation and improvement in EMLI has been linked to LS. This is because LS addresses many of the problems associated with teachers' classroom practices (Takahashi & McDougal, 2016). LS provides teachers with the opportunity to collaboratively plan lessons and implement them to meet the students' learning needs (Lewis

et al., 2019). LS is an instructional improvement model that places teachers at the center of pedagogical activity, with their interests and desires to better understand students' learning. It helps teachers to link their classroom teaching practice with broader educational goals and objectives. This linkage makes teachers more flexible and dynamic in using a variety of instructional methods to actively engage students in learning activities that transform their classroom practices (Lee & Madden, 2019). Teachers practicing LS, can learn new and better use of instructional methods, materials, and assessments and refine their skill of managing students' behavior (Kihwele, & Guoyuan, 2020). It creates a teaching situation based on students' knowledge that helps them to improve teaching methods to benefit students, particularly those needing support (Lundbäck & Egerhag, 2020). Hence, the true purpose of LS is not just about improving a single lesson but rather building pathways for ongoing improvement of instruction and students' learning (Takahashi & McDougal, 2016). It is about improving teachers' use of diverse teaching methods, student-based activity design, and better teacher-student interaction (Rahim et al., 2015). During the practice of LS, teachers systematically observe their colleague's classroom teaching from students' viewpoint helpful to improve their knowledge of student thinking and motivation to improve their instruction (Lewis et al., 2019). Hence, engaging in LS improves teachers' teaching, assessment, and feedback-related capabilities (Aimah et al., 2018).

Previous studies reported positive impacts of LS on mathematics teachers' EMLI (Adler et al., 2023; Roorda et al., 2024). A study conducted in Malawi secondary mathematics teachers showed that LS maximized teachers' teaching and learning (Adler et al., 2023). Similarly, a study in South Africa revealed that LS positively influenced mathematics teachers' creative teaching of mathematics (Helmbold et al., 2021). Hence, LS improved teachers' lesson delivery and practices of learner-centered pedagogy (Jung et al., 2015) and focused on students learning (Bikmaz, & Bayram, 2021). It enabled teachers to be monitored each other mainly in lesson presentation, teaching material preparation and usage, assessment and time management skills (Bikmaz, & Bayram, 2021). LS promoted teachers pedagogical skills and practices in lesson implementation, classroom management, and assessment through post-lesson reflections and peer observations (Rahim et al., 2015).

Although LS plays an important role in improving teachers' effective teaching practices, some school context-related factors influence teachers' EMLI. These include teachers' collaboration, administrative support, and availability of resources (Ogegbo et al., 2019; Wajdi, 2017; Wood & Cajkler, 2018). Teachers working in collaboration build a culture of learning from each other (Bikmaz, & Bayram, 2021). Teachers' engagement in LS also requires substantial support from school leaders in terms of administrative, material, and moral encouragement to promote every teacher's capacity building (Chiira et al., 2023). Secondary school leaders promote collaborative practices (team work, peer lesson observation, and team teaching) that support the implementation of LS in the school (Chiira et al., 2023). Teachers' engagement in LS is also impeded by teacher's workload which a lighter instructional load allows teachers to get time to best engage in LS activities (Akiba, 2016). Teachers also need adequate time to engage in various activities to make LS an ongoing part of their daily basis and to see the results of their effort (Wood & Cajkler, 2018).

Method

Research Design

This study employed design-based research (DBR), which is a systematic methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings (Wang & Hannafin, 2005). DBR is used for four main reasons. First, DBR indicates ways in which research in LS could be undertaken in a non-Japanese environment (Ebaeguin, 2014). The context of this study is, Ethiopia, the conditions might be different from Japan. Second, DBR is convenient for studies with cyclic and iterative (Anderson & Shattuck, 2012; Reeves & McKenney, 2013). In this study, LS was conducted in two cycles of iterations. Third, DBR is contextual where the practitioners are part of the context (Anderson & Shattuck, 2012; Juuti, Lavnen & Meisaol, 2016). This study conducted in the schools and classroom settings where teachers actually engaged in their regular mathematics teaching.

The Study Settings

Proponents of DBR advocate for context-based research to increase the relevance of research outcomes in a real context and to benefit the practitioners from research work (Armstrong, Dopp, Welsh, 2018). The settings for this particular study were positioned in two public secondary schools (grades 9 to 12), found in Jimma City, Ethiopia. For the sake of anonymity, the settings were named secondary school A and secondary school B.

Participants

Twelve mathematics teachers (eight males and four females) were the participants in this study. All participants had a first degree in mathematics an optimum educational qualification to teach at the secondary school level in the country. The teaching experiences of the participants ranged from three years to thirty years. In terms of grade assignment, four teachers were teaching at grade nine, four at grade ten, two at grade eleven, and two at grade twelve. Participants were grouped into two LS teams, based on their respective schools. Each team consisted of six teachers. The LS team at school A consisted of five males and one female, while the LS team at school B consisted of three males and three females.

Sample and Sampling Techniques

A purposive sampling technique was utilized in this study where the samples were deliberately selected to achieve the intended objectives of the study. Primarily, two out of six secondary schools were selected purposefully because the school leaders were open and willing to implement LS in their schools. Mathematics subject was focused purposively due to the emphasis given to improving the teaching and learning of mathematics subject in Ethiopia (focus on science and technology) and the serious problems faced in teaching the subject (Seifu,

2019). Teachers were also selected on a purposive basis based on their teaching experiences at all grade levels (grades 9 to 12) and willingness to take part in the study.

Data Collection Instruments

The data for the study were collected from interviews, observations, and document analysis.

Interviews

Semi-structured interview guide was prepared originally in English language and translated into local languages (Amharic and Afan Oromo). Before the use of interview guides, the questions were reviewed and checked by supervisors, researchers, and language experts. The interviews were scheduled before meeting the participants to ensure that they were present at a convenient location. Using a personal face to face interview, all the study team members were interviewed by the researchers at the end of the second cycle of LS implementation using either of the local languages, based on the interest of the participant. Each interview lasted for 30-40 minutes. All interviews were audiotaped.

Observations

The study team meeting observations were conducted during the four stages of the LS implementation process in two cycles. All meetings were observed by the researcher as participant observer and detailed field notes were kept. Four (two in each team) classroom research lessons were taught and observed by the study team members together with the researcher using a semi-structured observation protocol. The research lesson observations took four periods (each period lasted 40 minutes) and taught in grade 10 on the topic of *"Applications of exponential and logarithmic functions."* All observers stood in a position not to block students' view of the chalkboard and documented relevant data for 40 minutes. Some pertinent issues were video recorded by the researchers to provide evidence of the teacher and student engagement in the teaching and learning process.

Documents

Meeting minutes, reflective portfolio, and lesson plans were also used to secure supplementary data helpful for triangulation purposes. Accordingly, four detailed lesson plans (two in each team) were prepared, implemented, and examined. Besides, all meeting minutes were taken by minute takers and approved by the signatures of all participants at the end of each meeting. Further, all the study team members produced a reflective portfolio in which they documented their performance outlining their journey of participation in the LS processes. At the end of the study, all documents were collected and used as sources of data.

Implementation of the Intervention

The implementation of intervention began with one-day awareness-raising workshops on the basics of the LS and was implemented from November 2022 to May 2023. Then, two study teams were formed (one in each setting), and LS processes that involved four stages implemented in two cycles (one cycle in each semester) in both settings were described as follows.

Stage 1 Curriculum Study and Goal Setting

This stage involved six LS team members and one researcher in each setting. Participants studied mathematics curriculum materials (from grades 9-12), standards, and policy documents. They reflected on their teaching to address common classroom mathematics learning challenges that students have, and some teachers struggled to teach it. Thus, students' learning problem was identified as *"applications of exponential and logarithmic functions in real life"* as a gap, from grade 10, unit two. To this effect, both teams explored the same topic. Then, participants adapted learning goals from curriculum materials "*Students will be an independent problem solver*.' Both teams fixed a research question based on the goal to guide their study stating, *"How can we help students solve mathematical problems involving exponential and logarithmic functions independently from real life?"*

Stage 2 Planning

At this stage, participants collaboratively worked on a lesson plan. Participants again collaboratively studied the grade 10 mathematics syllabus, teacher's guide, and student textbook in detail and planned the research lesson around learning objectives to achieve the intended goal. Participants discussed and shared experiences on how to design a lesson so that students learn the topic of *"application of exponential and logarithmic functions in real life"* better than they have previously. They reflected on their experiences of lesson planning on the topic and shared experiences on the most appropriate learning path, materials, assessment, and time required for teaching and learning the topic. Besides, participants decided on the focus of data to be collected and the learning path "*the gradual release of responsibility (GRR) model"* (Fisher & Frey, 2008) to ensure better student learning of a topic as prescribed in the teacher's guide. In addition, the GRR model was found to fit for the intended research that required teachers to know their students and content very well, regularly assess students' understanding of the content, and purposefully plan lessons that transfer responsibility from the teacher to the student (Fisher & Frey, 2008). They anticipated students' mathematical responses and misconceptions related to learning the topic and crafted the lesson plan. The lesson plans were prepared with specific learning objectives in four chart columns: teacher's and students' activities including students' anticipated responses and misconceptions, teaching and learning aids, evaluations, and time allocated to the activities in minutes. Finally, each team collaboratively crafted the lesson plan centered on students' activities and assigned one of the grade 10 teachers voluntarily to deliver the research lesson during regular class time.

Stage 3 Conduct (Teaching and Observing)

The implementation of the collaboratively planned lesson has two main components: teaching the planned lesson and observing the lesson. Participants conducted two research lessons (one in each semester) in each setting. The research lesson was taught by one of the team members in grade 10 and other team members observed the lesson and collected data on students' learning. As the collaboratively planned lesson was taught by the classroom mathematics teacher, other LS members and the researcher observed the lesson using a copy of the lesson plan and collected data through notetaking based on observation protocol. The observation protocol is composed of three columns: teacher's actions and responses, students' actions and responses, and reflection on assessments. Observers examined data on student thinking, work, questions, responses, engagement, and behavior to the research theme focused on the lesson rather than the teacher.

Stage 4 Post-Lesson Reflections

In the post-lesson reflection all LS team members, one researcher, and a knowledgeable other person attended the meeting. A facilitator from the team members gave the first chance to the teacher who taught the research lesson for reflections, who commented on what went well in the lesson, challenges faced with teaching and learned experience to the expected lesson outcomes. The team members then presented their key observations turn by turn, focusing on the thinking and planning behind the lesson and taking collective ownership of the lesson. They discussed students' learning based on the data they collected during lesson observation. The focus of the discussion was to improve the lesson for better teaching and students' learning of the topic. Finally, adjustment was made to a refined lesson plan and re-taught by the same teacher in another classroom. Participants similarly collected and analyzed data.

Data Analysis

The audio-taped data collected from different sources were transcribed and translated into English language by the help of Google translation and checked by a language expert. The analysis was conducted based on the (Saldana, 2013) coding manual for qualitative researchers. The coding methods were based on the objectives of the study and basic research questions in two cycles. Primarily, the transcripts were coded inductively reading line-by-line, segmenting, labeling, and writing memos by directly examining the data based on emic terms (terms that were used by participants themselves). This was followed by deductive coding drawing upon basic concepts in research questions (Saldana, 2013). The codes were verified by working closely with the knowledgeable other person, to determine inter-coder agreement on codes. Then, similar codes were merged to form categories, interrelated categories were merged to form themes, and thematic analysis was conducted. The analysis carried out was supported by qualitative data analysis software called Atlas-ti. Further, pertinent verbatim quotes were extracted from each transcript and placed under the major themes to provide essential evidence.

Findings

The analysis of interviews, observations, and documents depicted three main themes. These themes were validated across the various data sources for each theme and analyzed as follows.

Theme 1: Managing Effective Lesson Implementation

The analysis of the interviews indicated that colleagues' teaching research lesson observation best modeled and shaped observers' lesson presentation experiences. Participants viewed their colleague's teaching observation as a golden opportunity to see how to make the lesson more understandable to the students and to share better pedagogical practice in the classroom. For many of the participants insight about best practices came from colleague's teaching observations and post-lesson discussions they had. Then, they adapted and integrated it into their practice. This was accurately summarized by a participant from school A who stated:

> "……The teacher began the daily lesson by greeting the students with welcoming faces. In the introduction, he motivated students and revised the previous lesson by asking questions. Students replied. Then, he communicated the daily lesson and learning objectives. In presenting the lesson, he wrote a problem to be solved, organized students using mixed-ability groups, and told them to solve it. He walked around, encouraged students' active participation, and provided hints. He gave a chance to students' group work presentation. Then, summarized the main points using teaching aids, asked questions, made students self-assess, and gave feedback. Finally, he gave homework and closed the lesson. Hence, I can say that my colleague's teaching observation highly shaped my classroom teaching experiences."

Another participant from school B shared, similar views:

> "My colleague's classroom teaching observation has better demonstrated to me how to present the lesson using students' knowledge and real-life related examples. He presented the lesson from simple to complex, from concrete to abstract matching the lessons to the students' mindsets and their learning paces to enhance their understanding. He used local examples and students' home-related experiences from their daily life."

The analysis of the interviews also revealed that participants' predominant use of teacher-centered teaching methods attributed to large class size, vast content to be covered, and lack of experiences gradually shifted to the use of more student-centered teaching methods. The colleague's classroom teaching observation had better demonstrated to observers how to move gradually from the traditional chalk and talk teaching methods into more student-centered classroom teaching. These helped them to improve their use of different student-centered teaching methods in their actual classroom teaching. Many of the participants confirmed that as they had begun to exercise and use different active learning strategies regardless of many challenges in the classroom. In this respect, one participant from school A suggested:

> "I felt that implementing student-centered teaching in a large class size (when students are more than fifty) would be impossible. However, I observed the use of gapped lectures, small group discussions, question and answer, problem solving, and cooperative work in one session. Within 40 minutes, I didn't see an off-task student. This has initiated me to practically use different student-centered/active learning methods in my classroom teaching. Thus, my colleague's teaching observation highly impacted my skill to facilitate students learning using more student-centered/active learning methods."

A participant from school B had similar views about the use of active learning strategies, and who stated:

> "From my colleague's research lesson teaching, I can observe the use of different active learning strategies. This is because my colleague used in one session; group discussion, pair work, buzz groups, debate, questions and answers, problem-solving, and individual work. I rarely use these active learning strategies due to a shortage of time to cover vast content and a lack of experience in using active learning methods. However, after observing my colleague's teaching, I can try and use different active learning methods in my classroom teaching."

The analysis of the interviews also depicted that colleague's teaching observation enabled participants to focus on student work, engagement, and behavior, rather than focusing on the teacher's ability to present the lesson. By keeping their focus on students' engagement and their interactions, observers gained vital insights into ways to improve their instructional practice. This was found to be a great experience for their developed skills and experiences of observing students' engagements in the learning process. Watching students working together carefully and attentively listening to them has strengthened participants' attention to focus on students' observation which is a new experience for many of the participants. Thus, colleague's classroom teaching observations strengthened participants' ability to see students' engagements, interactions, and actions in their learning process. In this regard, one participant from school A said:

> "Previously, classroom observations were meant to evaluate teachers. In the LS, what I observed were how the students learn, their interaction, and how they worked with a teacher. In my observation, I noticed first, the students worked with the teacher, then, students worked together under the guidance of the teacher, and individually practiced in front of their peers. The teacher walked around, and gave advice, guidance, feedback, and encouragement. My colleague's teaching observation improved my ability to observe students' engagements which is a new experience in my classroom teaching."

Further, the analysis of the interviews showed that collaborative research lesson planning, colleague's teaching observation, and post-lesson reflection had contributed to improved participants' skill in selecting and using instructional aids, assessment, and classroom management strategies that aligned with the objectives and content of the lesson. The discussions and experience sharing focused on the use of instructional aids fostered

participants' skill of using different instructional aids to address students' different learning preferences. In this respect, one participant from school B stated:

> "After observing my colleague's classroom teaching, I have used visual aids to address the learning needs of those students who prefer to learn through their sense of sight, explanations for those who choose to learn through hearing, and provide tasks to be done for those who like to learn by doing. This has strengthened my ability to assess students' learning styles and use different instructional aids to address their learning preferences."

Similarly, a participant from school A said:

> "From my colleague's teaching observation, I observed the use of visual aids, showing and telling, and hands-on exercises to address the diversified learning needs of students. This has increased my ability to identify students' learning needs and use different instructional aids to address the diverse learning styles of students in my classroom teaching."

The analysis of the interviews also indicated that collaborative research lesson planning strengthened participants' ability to select and use formative assessment helpful to collect information on students' progress. Colleague's classroom teaching observation helped participants to identify what students have learned to help them by using timely and relevant feedback. It also assisted participants in fostering students' learning progress and making decisions about what questions to ask next, and how to answer students' questions. In this respect, a participant from school A said:

> "Due to a large number of students and my attention to covering the vast content of the textbook, I rarely used classroom-based assessment strategies and feedback. My experience is, giving homework and doing sample questions. After observing my colleague's classroom teaching, I can use quizzes, classwork, worksheets, and marking exercise book. Besides, I can give timely feedback and record the results as soon as possible."

Similarly, another participant from school B said:

> "From my colleague's classroom teaching observation, I learned how important is to give students the chance to observe and share their answers. I liked how the teacher used worksheets and made students to self-assess. That was a very interesting experience that I shared and used in my classroom teaching."

The colleague's classroom teaching observation strengthened the participants' ability to observe, identify, and manage the students' behaviors so that they get well prepared for managing classroom behaviors. In this respect, one of the participants from school A said:

> "From my colleague's teaching observation, I got useful experience in managing student behavior. I observed the doers, disturbers, and silent listeners. To maintain classroom

> discipline, the teacher watched all the students. Sometimes he used eye contact, signals like putting a finger on his lips to stop misbehavior. He presented the lesson step-by-step in a clear sequence. I think he was well-planned and prepared to facilitate students' learning. Thus, I reflected on my teaching performance and adapted such helpful classroom management strategies."

The analysis of the study team meetings and lesson observations showed that participants were able to encourage students' active participation and collaborative engagements to learn from each other through discussion and sharing of ideas at their own pace. Most of the participants had almost similar approach to teaching the topic under discussion. Thus, in the second cycle of LS implementation participants used multiple strategies; buzz group, debate, problem-solving, cooperative learning, and students' presentation in solving a mathematical problem. Participants carefully observed students' engagement, collected data on student learning, and recorded what they had observed. In their discussion participants acknowledged the appealing atmosphere of making the lesson student-centered, and the dynamic nature of classroom interactions. In their post-lesson discussions, participants argued that collaborative work in the LS enabled them to adjust the content of the lesson to the student's real-life experience and narrowed the gap between lesson planning and its implementation in the classroom. The collaboration helped them to choose and use suitable instructional methods, materials, assessments, classroom management, and feedback strategies.

Further, the analysis of documents (lesson plan) depicted that collaborative research lesson planning had strengthened participants' skills to implement the different didactic stages in their lesson implementation. This was found to be valuable to motivate students before teaching, organizing them for group work, fostering interactions, and managing students' behaviors. Besides, participants' reflective portfolios showed that colleague's teaching observation provided them the chance to see and use better teaching, assessment, and classroom management strategies. It also strengthened participants' ability to observe students' work attentively during the instructional process vital to managing students' behavior and providing timely feedback to foster their engagement in classroom activities.

As a whole, the analysis of all data sources supported the emerging theme. LS fostered participants' managing effective lesson implementation.

Theme 2: Backing Lesson Study Practices

The analysis of the interviews depicted that the school leaders have shown positive interest and willingness to accept LS as teachers' professional learning model in their school contexts. The school leaders provided office, verbal encouragement, and refreshments support that encouraged participants to engage in the LS activities. This has created suitable conditions for participants' engagement in the LS activities during the study periods vital to improve teachers EMLI. In this respect, a participant from school B said:

> "The school leaders were open to accepting LS as a CPD model and provided us with refreshments such as bottled water, coffee, and tea, during LS team meetings. The leaders exempted us from some extra school activities carried out by teachers on opposite shifts and provided us verbal encouragement saying 'Keep going', 'You did a good job', etc."

Similarly, another participant from school A stated:

> "The school leaders cooperated with us and created a suitable working environment during the study periods. They provided our office for meetings. We didn't experience any session loss. We didn't also face a shortage of material supply. There was nothing that disturbed us when we met for discussions."

The analysis of the interviews also showed that participants' intrinsic motivation and commitment to working together and overcoming the traditional individual teaching experiences had played a helpful role. This had been reported as supportive by many of the participants, of which a participant from school A said:

> "The LS team members willingly come together to hold discussions, openly raise questions, and work together patiently. We enjoyed working and learning together because we were not imposed. LS activities were exclusively focused on professional matters: curriculum, teachers' work, student learning, and the teaching-learning process. This has created a positive interest, willingness, and motivation to engage in the LS process."

Another participant from school B explained:

> "Well, the weekends (Saturday and Sunday) are vacation days for teachers. Because the team members found engaging in LS to be valuable professional learning and interesting, we committed our vacation time to engage in LS. This has fostered our engagement in LS activities."

The analysis of the document (reflective portfolio) indicated that participants appreciated the school leaders' initiatives to extend LS to other departments and promised to work with the LS team to extend their LS experiences to other department teachers.

As a whole, the analysis of data sources supported the emerging theme. The school leaders' support along with the participants' commitment reinforced LS practice to impact EMLI during the study periods.

Theme 3: Impeding Lesson Study Practices

The analysis of the interviews depicted that participants' high weekly teaching load, and shortage of time as limiting factors during the LS implementation periods to build teachers' EMLI practices. In this respect, a participant from school A said:

> "The heavy teaching load (25 periods per week) has challenged us to exert full effort in portfolio development. In addition, LS team members were working in different shift systems in the school. This created a problem of having a convenient common time to engage in LS activities together."

Another participant from school B had similar views:

> "My main challenge during the LS implementation was the shortage of time. Because writing a reflective portfolio is time-consuming. It requires conducting self-assessment, self-reflection, and written reports. This was found to be tiresome due to the time limit and extra professional work in the school."

The analysis of the document (reflective portfolio) indicated that almost all participants underscored the high weekly teaching load and the shortage of time as inhibiting issues for their active engagement in the LS activities. These have hampered their detailed analysis, reflections and organization of reflective portfolio during the study periods.

In sum, the analysis of data sources supported the emerging theme. Teachers' high teaching load, and shortage of time, constrained participants' engagement in LS during the study periods.

Discussion

Teachers' EMLI is decisive in fostering students' mathematics learning outcomes. In response to the first research question, the findings of the study indicated that engaging in LS improved secondary school mathematics teachers' EMLI. LS improved participants' practice of lesson presentation, use of a variety of student-centered methods, assessment, behavior management, instructional aids, and time management strategies. These findings concurred with other studies (Jung et al., 2015) who found teachers' improved practices of learner-centered pedagogy, lesson presentation, teaching material preparation, and usage. It also agreed with (Bikmaz, & Bayram, 2021) who found teachers' improved assessment, aligned with (Aimah et al., 2018) who found teachers' improved time management skills and coincided with (Kihwele, & Guoyuan, 2020) who found teachers' improved managing students' behavior.

The findings of the study show that engaging in LS enabled participants to improve their EMLI helpful to teach mathematics in a better way through teamwork, sharing experiences, and reflective practices helpful to solve classroom teaching-related problems. Participants planned lessons collaboratively which helped them to move practically towards more student-centered

lesson implementation. Participants identified students learning problems, selected appropriate learning paths (GRR), learning materials, and assessment practices designed to provoke and support student thinking and learning- all are basic aspects of EMLI. Participants planned mathematics lesson connecting with the real world and students' life outside the mathematics classroom. In this study, engaging in LS enabled participants to realize planning and implementing lessons students' have more meaningful experiences and possess a personal connection to their own lives beyond a textbook. This was found to be valuable in promoting problem-solving, mathematical reasoning, creativity, and decision-making individually and collaboratively as central aspects of EMLI.

EMLI supports and promotes students' learning clearly showing the connection between what is taught and how well it is taught. In this respect, the findings of the study depicted that participants were practically able to move towards student-centered learning and stimulated students' active participation in the learning processes. The students were able to engage in multiple active learning strategies vital to promote their critical thinking, reasoning, problem–solving, and making sense of mathematics leading to their independence. These improved participants' experience of promoting students' active participation during the instructional process rather than focusing only on their presentation and a few of students who could participate actively. Thus, participants tried to make their teaching participatory and inclusive giving room for students to share ideas, ask questions, listen to other ideas, and learn collaboratively – which are essential attributes of EMLI.

Studies support that engaging teachers in LS contributed to teachers' EMLI (McSweeney & Gardner, 2018). To be successful secondary mathematics teachers must demonstrate major mathematics principles, methods, procedures, and frameworks within mathematical fields (Capua, 2021). In this regard, engaging in LS helps teachers to create opportunities to the students to develop abstract, logical, and analytical thinking to be competent in using mathematics to evaluate and solve problems both in schools and in real-world situations (Hidayati et al., 2021). It helps teachers to use a variety of instructional methods to actively engage students in learning activities and to be more creative in transforming their practices (Lee & Madden, 2019). LS creates a teaching situation based on students' knowledge that helps them to change and improve teaching methods to benefit students (Lundbäck & Egerhag, 2020). Engaging in LS facilitates teachers' meaningful mathematical discussions, to build a common understanding of mathematical concepts, principles, and arguments vital for their effective lesson implementation (Copur-Gencturk & Tolar, 2022). It also helps teachers to connect mathematical ideas that promote students' ability to apply and solve problems in the real world, showing the power and practicality of mathematics as an aspect of effective lesson implementation (Matić et al., 2020). This enhances teachers' interest in teaching mathematics as they see the relevance and value of mathematics teaching (Hidayati et al., 2021).

In this study, participants reflected upon what they know about their students, mathematics content, and their experiences of teaching it, which is a new paradigm in their mathematics teaching practices. Thus, engaging in LS enabled participants to improve their mathematics teaching skills and experiences and provided them with better opportunities to directly apply

what they learned into actual classroom teaching fundamental to foster students' learning outcomes. EMLI seeks to equip students with the mathematical skills and knowledge they need to find solutions focused on problem-solving approaches(Capua, 2021). Engaging in LS elevated participants' experience of using diverse continuous assessment strategies to enhance student's learning. Participants were able to assess their students' current level of mathematical understanding and able to use their knowledge to make key decisions concerning mathematical tasks, and actions that feed into the students' learning process. Participants used diverse teaching and learning materials that assisted them in providing better opportunities for students to interact, represent, and explore mathematical concepts. They used sequential lesson presentations that motivated students' engagement in learning activities, promoted their self-management, and reduced the problem of managing students' misbehavior. Thus, engaging in LS enabled participants' to conduct a respectful, non-threatening classroom atmosphere in which all students feel comfortable in making contributions - important features of EMLI. LS promoted teachers' pedagogical skills and practices in lesson implementation, classroom management, and assessment through post-lesson reflections and peer observations (Rahim et al., 2015). Further, colleagues' teaching observations, reflective discussions, and feedback on teaching helped the participants to transform their theoretical knowledge into practice and continue to reflect on and adapt what was learned as they taught- new paths to improve teachers' EMLI.

In response to the second research question the findings revealed both enabling and impeding factors. Regarding the enabling factors, the findings show that the school leaders found to be supportive for teachers of EMLI. This finding concurred with (Chiira et al., 2023) who found school leaders promoting collaborative practices in the implementation of LS for EMLI. However, these findings contradict (Özdemir, 2019) where school leaders did not provide support and did not encourage teachers to engage in LS. The findings of this study also indicated that participants' collaboration, commitment, and active participation during the study periods were one of the enabling factors that facilitated the practice of LS crucial for EMLI. This finding confirms with other studies (Ogegbo et al., 2019; Shingphachanh, 2018; Wood & Cajkler, 2018) where LS participants' collaboration played an active role in their EMLI.

Studies revealed that LS requires substantial support from school leaders to better support teachers' EMLI (Ogegbo et al., 2019). Besides, teachers' collegiality and willingness to collaborate are crucial for EMLI in LS (Ogegbo et al., 2019; Shingphachanh, 2018). In this study, it is encouraging that the school leaders had positive interest, and initiatives to improve mathematics teachers' EMLI. The school leaders understood the purpose of LS, were willing to implement the model, and motivated the LS team in their professional learning helpful for EMLI. These provided participants with better opportunities, motivations, time, and conducive work contexts to engage in LS activities which are vital for building teachers' EMLI. Equally important, participants were intrinsically motivated to engage in LS activities committing their vacation time. LS provided participants an opportunity for collaboration and shared responsibility for student learning – a novel practice in Ethiopian schools. In the country, teachers often work in isolation, managing lessons, and students learning with no input from

other colleagues. Engaging in LS showed them how collaborative endeavor and ongoing commitment in teaching matters to promote their EMLI in the school setting. Further, Participants' openness to share their experiences, and give and receive feedback from colleagues served as the foundation to establish a professional learning community in their schools crucial to enhance EMLI. Participants accepted joint responsibility for improving students' mathematics learning outcomes in the school that fostered their EMLI practices during the study periods.

On contrary the findings of this study indicated that the shortage of time and teachers' high teaching load hampered participants' professional learning engagement during the study periods. This finding concurred with other studies (Chiira et al., 2023) who found that limited time and heavy workload limited the success of LS practices that hampered teachers' EMLI. It also coincided (Ogegbo et al., 2019; Wood & Cajkler, 2018) where the shortage of time constrained teachers' learning. It also confirmed (Akiba, 2016) that heavy teaching load limited teachers' professional learning engagement through LS. Studies show that teachers need adequate time to make professional development an ongoing part of their daily basis and to see the results of their efforts (Wood & Cajkler, 2018). Despite the benefits attributed to the LS in improving EMLI, time is a constraint to engaging participants in the various activities (Matini & Emily, 2020; McSweeney & Gardner, 2018; Ogegbo et al., 2019; Saito & Sato, 2012). Teachers have different teaching periods and responsibilities. So it is difficult to find a common time for the team to engage in LS activities beyond their regular working hours (Matini & Emily, 2020; Mon et al., 2016). In addition, teachers' professional learning is influenced by teachers' workload in which a lighter teaching load allows teachers to get time to engage in professional learning that fosters EMLI (Akiba, 2016). In this study, mathematics teachers' high workload per week accentuated the lack of common time for the participants to engage in the LS activities. Thus, allowing LS participants' adequate time to plan, observe, reflect on lessons, and organize reflective portfolios is essential to promote EMLI. In addition, a reduced teaching load is vital to allow participants to better engage and concentrate on the LS activities to achieve the desired results.

Limitations

This study was conducted in a particular locality of the country. Hence, it is difficult to generalize to all secondary school teachers in the country. The study suggests further investigation in more secondary schools using quantitative evidence with a larger sample size to validate the research findings. Future studies should investigate the impact of improved teachers' EMLI on students' mathematics learning outcomes on larger scale.

Conclusion and Implications

Effective mathematics lesson implementation is critical to fostering students' learning outcomes. The findings of the study show that engaging in LS played a decisive role in improving secondary school mathematics teachers' EMLI. Participants were practically able to move towards student-centered learning which stimulated students' active participation in the learning processes. Participants used diverse continuous assessment strategies, teaching and learning materials, and properly managed students' misbehavior – all are crucial features of EMLI. Engaging in LS enabled participants to improve their mathematics teaching skills and provided them with better opportunities to directly apply what they learned to actual classroom teaching. Thus, LS promoted teachers' pedagogical skills and practices in classroom lesson implementation. Taken together, engaging in LS, fostered teachers' collaborative problem-solving, reflective practices, and decision-making related to mathematics teaching very essential to enhance students' mathematics learning outcomes. LS enabled teachers' construction of new knowledge about their classroom practice and made necessary pedagogical adjustments to respond to diverse learning needs of students. Teachers pulled their expertise together and managed their classroom teaching challenges that improved their EMLI. Teachers were able to question and challenge their traditional classroom teaching practices and strived to look for more students' active engagement in mathematics learning.

The findings also reveal that the school leaders' positive attitude, initiative to school-based teachers' professional learning, and teachers' commitment with determination to learn in their school contexts through LS were supportive and inspiring signal for improved EMLI. In addition, teachers' collaboration, commitment with determination to learn in their school contexts, active participation, and openness to give and receive feedback from colleagues during the study periods facilitated EMLI. The findings also indicated that the shortage of time and teachers' high teaching load per week impeded teachers' engagement in LS activities. This has also accentuated the lack of common time for the participants to engage in the LS activities. Thus, allowing LS participants' adequate time to plan, observe, reflect on lessons, and organize reflective portfolios is essential to promote EMLI. In addition, a reduced teaching load is vital to allow participants to better engage and concentrate on the LS activities to achieve the desired results that the schools need to overcome.

In conclusion, LS provided more a practical link between teachers' professional learning activities and actual classroom practices. Therefore, it would be crucial to integrate LS into the present school-based teachers' pedagogical capacity-building program in the country. The implication is that it would be beneficial to extend the merits of LS to other school subjects and more schools in the country based on their specific school contexts. The study also contributed to knowledge and a practical basis for further research how LS would be used to improve secondary school teachers' effective lesson implementation in mathematics in the secondary schools of the country.

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Corresponding author: Temesgen Yadeta Dibaba
Email: temesgeny2@gmail.com