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Retrospective Analysis of Lesson Planning in Microteaching Lesson Study among Mathematics Preservice Teachers

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Abstract. Student-centered teaching requires student-centered planning. However, the prevalent teacher-centered lesson-planning paradigm hinders preservice teachers (PSTs) in implementing student-centered mathematics teaching. The literature suggests that microteaching lesson study (MLS) can support PST to develop their lesson-planning paradigms. Hence, this study argues that MLS transforms paradigms. This is evidenced by the extent to which PST lesson plans improve following MLS and the reflections of PSTs on their experiences of an MLS-integrated methods course. This article reports the results of a "QUANT + qual" retrospective analysis of the lesson plans and reflections of nine groups of primary mathematics PSTs. The results reveal significant improvements in the quality of student-centered lesson plans, while the reflections indicate that MLS facilitated PSTs' understanding of student-centered teaching in mathematics and rewarding experiences. MLS transforms PST paradigms by presenting an unfamiliar and challenging teaching approach, the collaborative and cyclical process of planning, microteaching, observing, feedback, and revising, and it offers a safe, controlled, and supportive environment. Hence, this study concludes that MLS is an effective practice-based pedagogy for methods courses designed to support PSTs in developing a student-centered lesson-planning paradigm. The following design principles of MLS integration into mathematics methods courses are recommended: implementation of MLS with teaching through problem-solving; reconfiguration of timing of MLS activities to fit context; focus on retaining the challenge and difficulty of the task; maximization of technological tools. Further, this

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research strongly recommends in-depth design-based research on transformative practice-based pedagogies in teacher education.

Keywords: mathematics lesson planning; microteaching lesson study; student-centered; design research; pedagogies of practice

1. Introduction

Preservice teachers (PSTs) train in lesson planning as a core skill necessary for effective mathematics teaching. However, there is an ongoing debate over whether PSTs are well prepared to plan lessons after they have completed their teacher education program. Lesson plans are valuable for teachers because they articulate their beliefs, assumptions, and conceptualizations of content and serve as useful references for reflection and improvement (Y.-A. Lee & Takahashi, 2011). It can be very challenging for PSTs to design lessons from scratch (Lim et al., 2018), with many opting to revise ready-made lesson plan examples and internet-based resources without much thought (Prabowo et al., 2022; Ulusoy & İncikabi, 2023).

Further, the literature indicates that prevalent lesson-planning practices are more traditional or teacher-centered than student-centered (Chizhik & Chizhik, 2016; Zazkis et al., 2009). Traditional lesson planning focuses on what the teacher does rather than what the students think and do. This type of planning is problematic because contemporary educational theories and learning standards require student-centered instruction and, therefore, a student-centered lesson-planning paradigm (National Research Council, 2001; Department of Science and Technology—Science Education Institute [DOST-SEI] & The Philippine Council of Mathematics Teachers Educators [MATHTED], 2011).

While contemporary lesson planning practices in teacher education appear to be student-centered, evidence suggests that PSTs retain and prefer traditional paradigms—a teacher-centered approach to both planning and teaching mathematics lessons (Kartal & Tillett, 2021; Prabowo et al., 2022). Hence, PSTs' lesson-planning paradigms need to be transformed before they can effectively teach student-centered mathematics. This study investigates the effectiveness of a contextualized methods course for pedagogy in fostering student-centered lesson-planning paradigms among primary mathematics PSTs.

In the context of the Philippines, PSTs reportedly have an acceptable or high level of lesson-planning competence (Roble & Bacabac, 2016; Ramirez, 2020; Ponce, 2024). However, there is insufficient evidence about the extent of student-centered lesson planning. In contrast, there is plenty of evidence of the traditional paradigm. The prevalence of the traditional lesson-planning paradigm perpetuates teacher-centered teaching, underscoring the need for reform-oriented and practice-based activities which alter PSTs' teaching approaches (Grossman et al., 2009; J.-E. Lee et al., 2016; Kartal & Tillett, 2021). Among these activities, microteaching lesson study (MLS) can effectively transform lesson-planning paradigms for PSTs when integrated into a mathematics methods course (e.g., Fernández, 2005; 2010; Thabane, 2019). Hence, MLS has been integrated into the design of a methods course for primary mathematics PSTs at a Philippine university.

This article retrospectively analyzes the PSTs' lesson plan outputs and group reflections from the MLS-integrated methods course to answer the following questions: (1) To what extent did the group's student-centered lesson plans improve after the contextualized MLS? (2) What insights do the primary mathematics PSTs have from collaboratively reflecting on their MLS experience? Answering these questions extends the MLS literature by verifying the transformative capacity of MLS as a reform-oriented pedagogical approach in methods courses, while considering its different contextual affordances and limitations (da Ponte, 2017; Baldry & Foster, 2019).

Further, this research also affirms MLS as a pedagogy of practice that can develop core teaching practices, particularly lesson planning (Grossman et al., 2009; Lewis et al., 2019). Finally, this research provides mathematics teacher educators with practical design principles for methods courses to support them in developing student-centered lesson-planning paradigms among PSTs.

2. Literature Review

The literature review contrasts the two paradigms of lesson planning: teacher-centered and student-centered. In characterizing teacher-centered lesson planning, the review demonstrates its prevalence despite supposed student-centered policy and curriculum expectations in mathematics. The review justifies the need for research on transformative pedagogies of practice in mathematics teacher education.

2.1 Traditional Teacher-centered Lesson Planning Paradigm

Traditional or teacher-centered lesson planning is anchored in behavioral theories of learning (Chizhik & Chizhik, 2016; Zazkis et al., 2009). The approach, known as the rational means-end model of planning, involves teachers specifying lesson objectives, identifying teaching-learning activities to achieve them, and evaluating whether students have achieved those objectives. Other variations of this model, such as the backward design, are fundamentally the same but rearrange the order of the process with a different focus. Despite advances in cognitive and sociocultural understanding of learning, this approach sees teachers still operating according to a behaviorist perspective (Chizhik & Chizhik, 2016), often blindly following standard lesson templates (Zazkis et al., 2009).

Zazkis et al. (2009) describe teacher-centered planning in mathematics as content-heavy, with the main focus of the lesson often being to dispense knowledge, like a recipe to be followed. While content-heavy lesson plans can include activities that prompt students to think and interact, they remain teacher-centered if they are not planned in an anticipatory way, which would involve teachers considering in advance multiple possibilities for student cognition and social interactions and building on them (Cohen et al., 2003; Y.-A. Lee & Takahashi, 2011; Fujii, 2016). Hence, this traditional recipe approach to planning leads to the idea that successful teaching involves the complete presentation of the lesson plan (e.g., Ferrer, 2021).

These characteristics are evident in the recent literature on Philippine-based lesson-planning involving primary PSTs. While there is no explicit evidence of these characteristics, the measures and instruments used to describe PST lesson-planning difficulties and competence suggest a teacher-centered approach. For example, in describing difficulties in lesson planning, Ferrer (2021) portrayed lesson planning as emphasizing objectives and content rather than students and students' thinking. This contrasts with other researchers like Sahin-Taskin (2017), who describe PST's challenges in creating appropriate activities. Ramirez (2020) describes perceived skills in lesson planning with statements like "Objectives are stated in terms of student behavior" (p. 100).

Meanwhile, Ponce (2024) includes explicit references to student-centered lesson formats such as "4A's, 5E's, 7E's" (p. 51), though this researcher does not emphasize the value of anticipating student thinking processes and responses. Roble and Bacabac (2016) confirmed the lack of student-centered activities in PST lesson plans. The heavy emphasis on behavioral objectives, content-heavy planning, and the delivery of the lesson plan indicates that PSTs hold traditional and teacher-centered lesson-planning paradigms.

2.2 Student-centered Lesson Planning Paradigm

Student-centered lesson planning emphasizes the cognitive and sociocultural dimensions of learning as underpinning behavior. Cohen et al.'s (2003) instruction-as-interaction model embodies this perspective. In this model, instruction occurs through the complex interactions between the teacher, students, mathematics, and the classroom context (Herbst & Chazan, 2012). Chizhik and Chizhik (2016) argue that revisions to Bloom's taxonomy emphasize cognition over behavior. For example, the domain 'knowledge' was revised into 'remembering', emphasizing the process (verb-form) rather than the outcome (noun). Nevertheless, teachers still cling to the behavioral interpretation of objectives despite the cognitive domain's reformulations.

Zazkis et al. (2009) refer to student-centered planning as process-heavy, emphasizing how students learn mathematics content. Planning for student learning, predicated on classroom interactions, requires teachers to anticipate the possibilities and contingencies of student-teacher, student-student, and student-content interactions within the classroom (Cohen et al., 2003). In this paradigm, the lesson planning anticipates a dialogic co-construction of meaning, anchored in a meaningful, challenging, and engaging mathematical task (NRC, 2001; Takahashi, 2021). Hence, there are key ways that the student-centered planning paradigm differs from the teacher-centered paradigm; these differences include a greater focus on students' thinking during activities and a deeper elaboration of teacher-student-content interactions, anticipating a contingent, dialogic co-construction of meaning.

2.3 Microteaching Lesson Study as Practice-based Pedagogy

MLS is a pedagogy that combines microteaching with Lesson Study (LS) (Fernández, 2005; 2010). Fernández (2005) defines traditional microteaching as PSTs presenting "scaled-down lessons to small groups of peers, receiving feedback on their performance from peers and supervisors" (p. 38). Microteaching provides an avenue for PSTs to develop teaching skills and opportunities for teacher educators to provide relevant feedback to PSTs. Mukuka and Alex (2024) argue that microteaching remains one of the most effective methods of inducting PSTs into teaching practice. LS is a collaborative professional development model originating in Japan. Y.-A. Lee and Takahashi (2011) claim that it provides a mechanism for teachers to anticipate student thinking by considering possible solutions to mathematical tasks. Through LS, teachers anticipate the interaction and development of concepts from these possible solutions.

Fujii (2018) describes a typical LS as having the following stages: (1) setting and clarifying learning goals; (2) planning for the lesson — a deep study of content, designing tasks, anticipating possible solutions, and concept development paths; (3) implementing the plan and gathering data about the plan; (4) discussion of the lesson implementation, whether the goal has been achieved, and how the lesson may be improved; and (5) reflection to develop relevant knowledge about teaching the content. LS differs from other collaborative educational design or research frameworks in that it aims to support professional development, focuses on a single lesson, is concerned with optimization of student learning, and is anticipatory (Bakker, 2018). MLS combines the benefits of the reduced complexity of practice in microteaching and the deliberate professional development process of LS (Fernández, 2010).

In the practice of Japanese LS, Teaching through Problem-Solving (TTP) has emerged as the main pedagogy for teaching mathematics in schools (Fujii, 2016; 2018). TTP currently consists of four parts: the teacher presenting the problem; students solving the problem; whole-class discussion and comparison; and summarizing (Fujii, 2016; Bataluna et al., 2021; Takahashi, 2021). The connection between LS and TTP implies that student-centered planning will inevitably produce a student-centered teaching approach.

LS is highly effective which is why it has been adopted for PST education, in formats such as MLS (e.g., Fernández, 2005; da Ponte, 2017; Kurt & Çakıroğlu, 2025). The effectiveness of LS in promoting reform-oriented mathematics practice among PSTs can be attributed to the pedagogy of practice theory (Lewis et al., 2019). Pedagogies of practice, or practice-based pedagogies, in teacher education help PSTs develop core or high-leverage teaching practices such as establishing culture in the classroom and leading classroom discussion (Grossman et al., 2009). As a practice derived from LS, MLS is more limited, in terms of exposing PSTs to real classroom contexts, but does allow for near-authentic representation, decomposition, and approximation of practice (Charalambous & Delaney, 2020). Hence, integrating MLS into the mathematics teacher education curriculum aligns well with the aims of the methods course, which focuses on lesson planning and teaching (J.-E. Lee et al., 2016).

There have been many studies on the use of MLS to develop PST teaching skills in various contexts (e.g., Thabane, 2019; Sukmawati & Purbaningrum, 2020; Murtafiah & Lukitasari, 2016; Mukuka & Alex, 2024; Kurt & Çakıroğlu, 2025). Results from these studies confirm Fernández's claims regarding the efficacy of MLS in developing various aspects of pedagogical content knowledge (PCK). However, contextualized efforts to explicate the transformation of PSTs' lesson-planning paradigm, a specific facet of PCK, through MLS, are lacking. Hence, analyzing the impact of this contextualized MLS integration from a design perspective extends the ecological validity of MLS as a practice-based pedagogy (Gravemeijer & van Eerde, 2009). Furthermore, it provides opportunities to develop empirically-based design principles for mathematics methods courses (McKenney & Reeves, 2014).

3. Methodology

This research adopts the design research framework of Gravemeijer and Cobb (2006). Design research aims to solve practical problems innovatively while expanding knowledge (McKenney & Reeves, 2014). Hence, this methodological framework is a design experiment in three phases, involving: preparation, implementation, and retrospective analysis. The design experiment preparation and implementation are described in Section 3.1. The retrospective analysis utilizes a descriptive "QUANT + qual" research design (Creswell & Guetterman, 2021, p. 598). The rigor and systematicity expected of educational design research are satisfied by triangulation of the data and the involvement of critical friends (McKenney & Reeves, 2014).

Critical friends are members of a community of practice that are not involved in the design process. In this research, they are Authors 2-4, colleagues of Author 1. Their involvement in both the data gathering and analysis procedures aims to provide unbiased outsider evaluations and perspectives that enrich the reflection process (Nelson, 2008). This research gathered PST outputs from the MLS-integrated methods course for analysis. Quantitative data are generated by assessing the outputs using rubrics, while qualitative data are PSTs' written reflections.

3.1 Design Experiment Description

The mathematics methods course is a 3-unit course offered as part of a primary teacher education program; it consists of a 2-unit lecture and a 1-unit laboratory. In this arrangement, the PSTs attend a two-hour lecture class per week and a three-hour laboratory class. The rationale for this lab class is to provide more time for the PSTs to apply the principles and theories from the lecture. The course is guided by the microteaching lesson study process. The contextualized MLS is based on the characteristics of MLS outlined by Fernández (2005), namely: (1) it is based on LS; (2) it is collaborative and recursive, i.e., involving multiple cycles of the LS process; (3) it requires instructor feedback; and (4) it involves microteaching with peers. Unlike Fernández's design, MLS was conducted sequentially and in person to provide immediate post-implementation feedback, rather than simultaneous microteaching with delayed feedback based on video recordings. This is based on the local practice of LS in the same region in the Philippines (Buan et al., 2021). Table 1 describes the process by which the intervention program was implemented.

3.2 Research Participants and Ethical Considerations

There were N=38 primary preservice teachers enrolled in this mathematics methods course. These PSTs were divided into 9 groups made up of 4-5 members each. At the beginning of the methods course, informed consent was obtained from the students, who agreed for the instructor (first author) to use their outputs for research after the course. The outputs were: a copy of their final assessment requirement for the course, a compilation portfolio containing (1) initial and (2) final lesson plans, and (3) group reflections. All data were gathered based on the aforementioned documents. While this classroom-based action research did not require ethical clearance from the university ethics committee, sufficient care was taken to ensure that no coercion of PSTs was involved in the study and no harm came to them.

Table 1: Design experiment overview

Lesson Study	Contextualized MLS	Session	Duration in Minutes
Pre-LS Orientation	Lecture on teaching through problem-solving Demonstration of a TTP lesson Post-lesson discussion on the lesson demonstration	1	60 30 30
Goal Setting	Lecture on LS process Workshop on selecting competencies and analyzing curriculum	2	40 80
Lesson Planning	Workshop on adopting or developing mathematical tasks and problems Peer and instructor feedback on select mathematical tasks and problems	3	80 40
	Workshop: PST groups (4–5 per group) draft their lesson plans, then submit them after a week; then, the group revises the lesson plans for microteaching	4	120
Implementing, Post-lesson Discussion and Reflection	Microteaching Cycle 1 Implemented by first pair (20 mins) to 2 other teams as students -> Post-lesson discussion with team and instructor feedback (10 mins) -> Revise lesson	5, 9 sessions	40/ session
	Microteaching Cycles 2/3 Implemented by the second pair/last member (20 mins) to 2 new other two teams as students -> Post-lesson discussion with team and instructor feedback (10 mins) -> Revise lesson -> Finalize lesson for submission	6, 11 sessions	40/ session
Post-LS Orientation	Groups write reflections and document the evolution of their lesson plans, supported by observation notes and individual and group reflections for summative evaluation	-	-

3.3 Data Collection and Analysis

Quantitative data were generated by reassessing the initial and final lesson plans using an adapted rubric for TTP lessons. A 4-scale lesson plan rubric was adopted from Bataluna et al. (2021) to guide three independent raters to rate the lesson plans; there was acceptable overall reliability ($\alpha_{Pre} = 0.77$; $\alpha_{Post} = 0.91$). The pairwise interrater reliability measure indicates a range from very little to substantial agreement on the ratings (κ_{Pre} = 0.07–0.88; κ_{Post} = 0.01–0.14). This confirms each rater's unique and independent interpretative assessment of the PSTs' outputs.

The rubric's criteria for the core lesson plan sections were analyzed and were as follow: Objectives (OBJ), Problem (PRO), Possible Solutions (PSO), Development of Concept (DOC), Assessment (ASS), and Closure and Generalization (CAG). The lessons were re-assessed by two other evaluators (Authors 3 & 4), in addition to the instructor, to provide an unbiased evaluation. Concurrently, qualitative data were collected by de-identifying eight group reflections (one group did not submit a reflection) and re-encoding the text. The prompt "Reflect on your MLS experiences concerning the core goals of mathematics education" generated the group reflections. The broad, open-ended, and neutral reflections serve to triangulate the lesson plan ratings.

Quantitative data were analyzed using descriptive and inferential statistics (frequencies, means, Shapiro-Wilk tests for normality, t-tests). These analyses provided insights into which aspects of the lesson plans improved. Each category's mean rating was interpreted using the 4-scale ranges: 1.00–1.75, Unacceptable [UN]; 1.76–2.50, Needs Improvement [NI]; 2.51–3.25, Acceptable [AC]; 3.26–4.00, Satisfactory [ST].

Qualitative data were analyzed using Bingham & Witkowsky's (2022) five-phase qualitative analysis process: organizing, sorting, understanding, interpreting, and explaining. In Phase 1, the written reflections were de-identified and coded. Then the text was deductively sorted, sentence by sentence, using the topic codes: TTP, MLS experience, and PST learning. Within each topic code cluster, three authors independently open-coded the data to understand them better.

In Phase 4, all the authors met to compare, discuss, and finalize their respective interpretations of the data. As a result, the codebook was refined, and the final codes were defined. As a rule, a code was considered in the final generation of themes when it appeared in at least three groups. Upon the authors' agreement, the codes were linked to form coherent themes, as explained in Section 4.2.

4. Results, Findings, and Discussions

The quantitative results followed by the qualitative findings are discussed in this section. Discussions for the results and findings are embedded in the respective sections.

4.1 Lesson Plan Improvement

This section describes how lesson plans produced by nine (9) groups improved after undergoing the contextualized MLS. These lesson plans follow the TTP instructional approach described in Section 2.3. As shown in Table 2, the PSTs' lesson plans improved from Needs Improvement (NI; M = 9.18, SD = 1.98) in their initial lesson plans to Acceptable (AC; M = 14.48, SD = 2.36) in their final lesson plans. However, none of them reached the highest expected Satisfactory (ST) level.

The Shapiro-Wilk test indicated that the total mean ratings for the lesson plans were normally distributed ($SW_{Pre} = 13.36 > 0.829$, $SW_{Post} = 18.31 > 0.829$). Hence, a t-test was conducted to confirm whether the difference is significant. The result shows that the mean difference of 5.30 (SD = 2.20) is significant, with a very large effect size (d = 2.406 > 0.8). The quality of outputs significantly increased after the MLS cycles. However, since the sample is very small, the generalizability of this result is limited. Regardless, the analysis of each criterion gives further insight into the aspects of planning that most improved for PSTs.

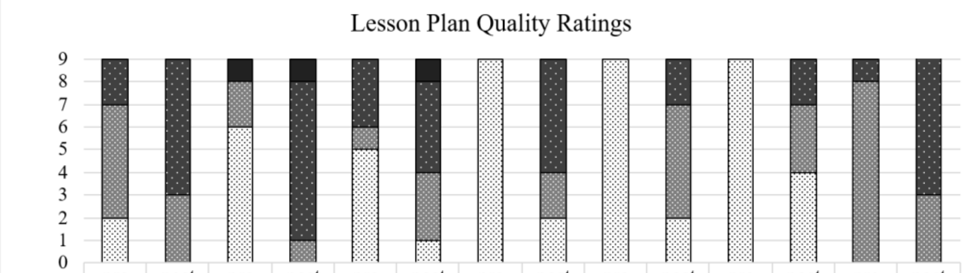
Table 2: Comparison of total average ratings between pre- and post-test ratings

Lesson Plan Total Ratings	Mean (n=9)	SD	df	t Stat	P	t Crit	Cohen's d
Initial Lesson Plan	9.18[a]	1.98	8	-7.21	0.00[b]	2.306	2.406[c]
Final Lesson Plan	14.48	2.36					

Note: [a] *Interpretation: 1.00–6.50, Unacceptable [UN]; 6.51–12.50, Needs Improvement [NI]; 12.51–18.50, Acceptable [AC]; 18.51–24.00, Satisfactory [ST]*
[b] *Significant at a = 0.05 (two-tailed).* [c] *Very large effect size d > 0.8*

Figure 1 illustrates the frequencies of qualitative ratings per criterion. The analysis reveals that the most radical changes in the lesson plans produced were in the areas of DOC and ASS. DOC anticipates the whole-class comparison and discussion of solutions to the problem, which builds and negotiates a shared understanding of the mathematical concepts or procedures emerging from learners' varied solutions. This whole-class negotiation of mathematical understanding is the core feature of TTP (Takahashi, 2021).

Surprisingly, this area showed the greatest average improvement despite professional teachers finding this stage the most difficult (Fujii, 2016). Concerning ASS, the initial, numerous rote assessment tasks evolved into meaningful extension problems. These extension problems apply the mathematics concepts and procedures learned to different contexts. Although these summative assessments are rarely implemented in microteaching, due to time constraints, critical feedback on this area significantly improved PSTs' plans.



	OBJ		PRO		PSO		DOC		ASS		CAG		TOTAL	
	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
ST	0	0	1	1	0	1	0	0	0	0	0	0	0	0
AC	2	6	0	7	3	4	0	5	0	2	0	2	1	7
NI	5	3	2	1	1	3	0	2	0	5	0	3	8	3
UN	2	0	6	0	5	1	9	2	9	2	9	4	0	0

Figure 1: Visualization of the PSTs' lesson plan quality ratings

In addition to these areas of the lesson plan, there were also significant changes for PRO, CAG, and PSO. The PRO, on which the TTP lesson hinges, must be appropriate and challenging (Fujii, 2016; NRC, 2001). Mathematical tasks in TTP can be used in series to develop conceptual and procedural understanding, and as stand-alone tasks to deepen understanding or explore mathematical ideas through open-ended tasks (Takahashi, 2021). The PSTs improved the appropriateness and open-endedness of the mathematical tasks in their lessons.

The improved tasks better addressed the grade-level standards and elicited multiple approaches and solutions, rather than a single correct answer. Similarly, the PSO section of the lesson plans improved so that the anticipated responses were more appropriate for the learners' level. Fujii (2016) noted that anticipating student solutions considers both the "slower" and "faster" (p. 419) students. The PRO and PSO are essential in developing the plan for DOC and CAG.

Regarding the CAG, initial plans called for teacher-led summarization or overestimating students' capacity to synthesize concepts. The final plans included more realistic, scaffolded summarizations. Lastly, there was little improvement in stating objectives, as the PSTs demonstrated competence in articulating them, in accordance with the behavioral principles of clarity, measurability, appropriateness, reality, and time-boundedness. However, PSTs' abilities to consider prior competencies when formulating appropriate and realistic objectives can still be improved.

The results demonstrate that the PSTs produced significantly better student-centered mathematics (TTP) lesson plans after the MLS. At the core of this improvement was the PSTs' newly acquired ability to anticipate classroom dialogues that would lead to the development of mathematical concepts or processes. This demonstrates that MLS promotes the anticipatory characteristic of student-centered planning for classroom contingencies (Chizhik & Chizhik, 2016; Zazkis et al., 2009). In particular, MLS supported the planning interactions among the teacher, the learners, and the content (Cohen et al., 2003; NRC, 2001; Takahashi, 2021).

4.2 Transformation of the Lesson Planning Paradigm

This section discusses the three thematic findings based on the written reflections of the eight (8) groups. The findings highlight the PSTs' perspectives on TTP as a student-centered teaching approach in mathematics (4.2.1), on their MLS collaborative experience (4.2.2), and the outcomes of the MLS (4.3.3).

4.2.1 *Theme 1: A student-centered approach is more challenging and demanding*

As a student-centered approach, the TTP aims to move beyond the lecture method of simply telling or explaining content (Fujii, 2016; Takahashi, 2021). TTP uses well-designed tasks that allow students to discover concepts themselves with their peers. The teacher then facilitates the exchange, comparison, and negotiation of students' ideas, reasons, and questions to arrive at a common understanding of mathematics (Takahashi, 2021). The results revealed that PSTs (4 groups) explicitly reflect on their understanding of TTP goals. However, even among those who understood its goal, there remained doubts:

> *"[TTP] is one of the best ways of teaching, especially in Mathematics. We are wondering if we can really apply this kind of strategy in an actual classroom setting." (G2)*

This doubt is reasonable. In fact, research from the same region involving professional teachers reported the same doubt, citing school systems which were unsupportive of student-centered pedagogies such as TTP (Buan et al., 2021). In addition to the prevalent unsupportive school contexts, TTP demands more effort than traditional approaches. Firstly, in a culture where lecturing is the norm, problem-based pedagogies like TTP demand a radical departure from conventions:

> *"Different from the customary … first time to apply." (G5)*

The second demand is to develop and adopt appropriate and meaningful problems. As the problem facilitates the representation of and engagement with learners' and peers' thinking, the whole lesson is anchored on its appropriateness (Fujii, 2016). Hence, a greater understanding of mathematics is required from the PSTs:

> *"You can't just simply create whatever problem. It should be open for different solutions. [We] will not be able to provide adequate knowledge to students if we do not sufficiently elaborate on the topic." (G2)*
>
> *"We had a hard time making mathematical problems that would capture their attention and be challenging, realistic and relevant for the learners. [We] must also possess [critical thinking and problem-solving] skills." (G7).*

The third demand is to develop a deeper understanding among students to facilitate better discussions. This demand entails pedagogical content knowledge relating to students (see Ball et al., 2008). Anchored in this knowledge of students is the ability to make pedagogical decisions in real time. This includes handling unpredictable classroom contingencies and documenting student thinking through board-writing. Since planning board-writing is critical in planning TTP lessons (Takahashi, 2021), it inevitably adds to the demand for lesson planning:

"Since we are handling grade 1, [we] should be careful in using words. [We] should [use] common words that are understandable so that it is easy for them to receive and analyze the statement. [Not] vague statement or explanation that will lead to misconceptions." (G5).

"[We] must be flexible enough to combine student feedback and make quick adjustments depending on specific classroom circumstances." (G1)

"[We] pose follow-up questions, taking into account the students' critical thinking abilities. And as we have observed, this type of teaching, board writing often appears spontaneous because it includes ideas and student work that emerge during the lesson. Students who become distracted during the lesson can return to the lesson's ideas and re-enter the lesson [through the board-writing]." (G9).

Despite the long list of demands placed by TTP on the PSTs, they confirmed that TTP is indeed student-centered. Moreover, despite its challenges, TTP is still doable:

"Students develop their mathematical reasoning skills as they gain knowledge of the subject, see how their … written explanations [can help] their classmates and themselves understand difficult concepts and have their perseverance naturally deepened by mathematical discoveries." (G1).

"[Our peers] were able to share and exchange their ideas. We were so amazed when one student raised her hand to clarify the answer of her classmate. It was a good interaction." (G2).

"We have succeeded in asking questions that lead to mathematical understanding and in having people reflect on what they have learned." (G7).

The PST groups found the TTP approach challenging and demanding since it is an "advanced pedagogy" (Takahashi, 2021, p. 7). Nevertheless, the PST reflections indicate that TTP engages students in self-directed learning, facilitated by peer and teacher interactions, as they make sense of mathematics while solving problems. These characteristics of student-centered learning demand from teachers a deeper understanding of the content and students' thinking processes. Such understanding is the basis for anticipatory planning and flexible facilitation of whole-class discussions, where students learn mathematics without being lectured (NRC, 2001; Takahashi, 2021).

4.2.2 *Theme 2: Microteaching Lesson Study is challenging but rewarding*

The MLS task required the PSTs to develop, implement, and refine a TTP lesson. PSTs perceived the collaborative task as challenging and rewarding. As demonstrated in the previous theme, unfamiliarity stemmed primarily from TTP being a non-conventional teaching approach. In addition, some groups noted challenges in communication, misunderstandings or collaboration challenges due to pressures outside the task and differences in family backgrounds:

"There are lots of hindrances that create misunderstanding and misconception throughout. Sometimes we tend to intensify our emotions." (G6)

"We encounter difficulties and problems, especially because of too many pressures from different subjects and too many homework assignments and due dates to be passed, and also different family backgrounds." (G4)

In the context of these challenges, groups employed collaborative strategies, including cooperation (G6), taking strategic pauses for "'aha!' moments" (G5), dividing tasks (G5), and group discussions to interpret and incorporate feedback to improve lessons (G7). In addition to these strategies, some groups further described dispositions that helped them navigate group dynamics, such as gratefulness (G4), trust and appreciation of one another (G6), resilience and hard work (G7), and openness and teachability (G5). By way of illustration, one group reflected:

"The lesson plan implementation activity is really a great opportunity to work with different people and achieve the goal if you just work as one. There were a lot of hits and misses, but it did not make us stop there. It was our driving force to keep going and improve, rather than get discouraged. After every implementation, the implementer would always ask, 'What did I miss?' It was a clear manifestation that, in our group, we were open to critique and conversation, and we helped each other become better." (G5)

Others found it helpful to keep certain considerations in mind as they worked through the task. These considerations focused on ideas related to the task output or peers. In terms of the task output, groups recalled the purpose of the lesson plan as a guide, highlighting that the lesson should be well organized (G2) and considering the importance of primary mathematics lessons as foundational for future learning (G7). Others emphasized considerations relating to group mates, such as frequent communication (G6) and recognizing burnout and the need for rest as a team (G5). These considerations facilitated both task completion and PST collaboration.

The collaborative nature of MLS allowed PSTs to actively engage with peers in designing a student-centered mathematics lesson. As the evidence suggests, PSTs navigated the challenging task by employing strategies, adopting productive dispositions, and considering task- and group-related factors, which helped them accomplish it. These factors demonstrated to the PSTs that the MLS experience is challenging, worthwhile, and rewarding:

"All in all, we are happy that we were able to experience this way of teaching. It was really a great experience that we look forward to in our own class in the future." (G2).

"It was quite a challenging responsibility. ... As a result of our cooperation and teamwork, it was all rewarding." (G7).

These PSTs' reflections on the challenge and their respective ways of navigating it highlight the importance of working in groups (Fernández, 2005). Similarly, these pieces of evidence affirm the value of LS, which inherently engages teachers in communicating and negotiating concepts and beliefs that are eventually reflected in their lesson plans (Y.-A. Lee & Takahashi, 2011). From the planning process to the microteaching and lesson revision, the PSTs reflected on how MLS transformed their task outputs and their thinking about mathematics teaching and planning.

4.2.3 *Theme 3: Microteaching Lesson Study is transformative*

The PSTs found the MLS experience to be transformative, evidenced by their explicit reflections on the iterations of their plans and their thinking. PSTs attributed such transformation to specific aspects of the MLS process: the cycles, critical feedback, and reflection. In describing the changes in their lesson plans, PSTs (five groups) mostly recalled the MLS cycles and the feedback received as relevant:

> *"When we started our first cycle, our competency and problem were not aligned. We modified our strategy in response to the comments and suggestions made by our professors and classmates. [W]hen we are on our final cycle, [t]here has been significant progress." (G7)*

Others noted the importance of taking on different roles during microteaching and how these roles led to deeper reflection (observer, implementer, and documenter). As TTP demands higher expectations from the preparation of teachers, some groups expressed the need to live up to this expectation. They eventually realized one of the core characteristics of student-centered planning: facilitating the co-construction of meaning by connecting learners' ideas:

> *[We] failed to produce TTP during the first implementation. Revisions from top to bottom were made to achieve the desired outcome, the expectation of TTP. We understand the concept, but connecting it altogether, such as in incorporating the learners' different approaches to the problem, their strategies or methods used to solve the problem, and how it is connected to the lesson, is what we are trying to conceptualize. (G8).*

Overall, the MLS experience enabled the PSTs to realize that they needed to change their paradigm in mathematics teaching. One group recalled a common mnemonic from the traditional dispensatory teaching method, *"I do, we do, and you do."* And then rephrased it as *"you do, we do, we generalize"* (G1), reflecting the reform-orientation of the TTP process.

Based on the themes, PSTs' paradigms were transformed by the introduction of a challenging student-centered teaching approach, the TTP (Theme 1). The sense of uncertainty about the task was a critical factor in the paradigmatic transformation (Shulman, 2005). The MLS-integrated methods course intervention, characterized by collaboration, cyclical planning, microteaching, observation, feedback, and revision, supported this transformation and led to a rewarding experience (Themes 2 & 3). The qualitative results confirm the claims that MLS provides a safe, controlled, and supportive environment in developing reform-oriented teaching skills (da Ponte, 2017; Fernández, 2005; Mukuka & Alex, 2024). The representation of practice through demonstrations, decomposition of practice through scaffolded workshops, and approximation of practice through microteaching, which the PSTs experienced, supported paradigm transformation (Grossman et al., 2009; Charalambous & Delaney, 2020).

The significant improvement in the TTP lessons, corroborated by thematic findings, provide triangulated evidence of the transformative capacity of MLS as a practice-based pedagogy for methods courses. The findings of this study confirm similar findings in other contexts. This research affirms, among other things, on the view among PSTs that MLS is a supportive approach to improving practice (Thabane, 2019) and improving various facets of PCK (Kurt & Çakıroğlu, 2025; Murtafiah & Lukitasari, 2016). The need for more time, scaffolding, instructor feedback, the use of technology, and real classroom experiences is also highlighted (Mukuka & Alex, 2024).

However, this research presents a unique perspective in that MLS is explicitly used to shift PST's paradigms toward student-centered mathematics teaching. Research on this explicit aim towards reform-oriented math instruction in similar contexts has been lacking to date (Murtafiah & Lukitasari, 2016; Sukmawati & Purbaningrum, 2020). Finally, this research provides the pedagogy of practice theory as a viable framework for more innovations on transformative pedagogies in teacher education.

5. Conclusion

This article demonstrates that the MLS-integrated methods course pedagogy transformed the lesson planning paradigms of primary mathematics PSTs. This retrospective analysis provides triangulated evidence of the transformation from a teacher-centered to a student-centered paradigm. The qualitative themes support the significant difference in the lesson plan ratings. The combined quantitative measures, along with the themes generated from the collaborative reflections, provide evidence supporting the claim that MLS is a transformative, practice-based pedagogy for methods courses.

Therefore, this study concludes that MLS should be used in mathematics methods courses. MLS's transformative capacity is attributed to the following characteristics: (1) it presents an unfamiliar and challenging approach to teaching; (2) it involves a collaborative and cyclical process of planning, microteaching, observing, feedback, and revising; and (3) it offers a safe, controlled, and supportive environment.

Based on the empirical insights from this study and relevant literature, we recommend the following guidelines in integrating MLS to mathematics methods courses: (1) introduce MLS to demonstrate and enable PSTs to learn a student-centered pedagogy, particularly TTP, as described in Section 3.1; (2) reconfigure the timing of the MLS so that it fits into the timeframe of the methods course, as applicable and provide sufficient scaffolding and time for planning due to MLS's anticipatory and contingent characteristics; (3) retain degrees of difficulty and uncertainty and maintain high expectations in presenting the task and giving feedback as appropriate; (4) maximize the use of video recording tools to facilitate evidence-based reflections and feedback because videos afford deeper and more detailed examinations of classroom interactions. Lastly, we strongly recommend more design-based research on transformative practice-based pedagogies like MLS. In addition to examining the design outcomes, in-depth data collection methods that capture PSTs' real-time experiences can provide a richer elaboration of their learning process.

6. Conflict of Interest

The authors declare no conflict of interest.

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