Investigating how and what prospective teachers learn through microteaching lesson study

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Abstract
Microteaching Lesson Study [MLS] combines elements of Japanese lesson study and microteaching. A case study of MLS was conducted with 18 prospective teachers in an initial course on learning to teach. Various data sources (i.e., pre- and post-lesson plans, MLS lesson plans, videotaped lessons, transcripts of group discussions, observation field notes, MLS group written reflective reports and feedback surveys) were triangulated. The pre- and post-lesson plans demonstrated growth in participants’ knowledge of teaching aligned with an overarching student-learning process goal (i.e., mathematics reasoning). Active learning involving meaningful discussion, planning, and practice, support from a knowledgeable advisor, collaborative deliberation-in-process, and opportunity to trial, analyse and revise were aspects of MLS revealed as centrally important for prospective teacher learning through MLS.

1. Introduction
Research is needed on pedagogical approaches and experiences that support teacher educators’ efforts to inspire prospective teachers’ learning and help them develop knowledge and practises aligned with recent reforms (Grossman, 2005; National Academy of Education [NAE], 1999). Researchers recommend seeking experiences that provide shared contexts for prospective teachers’ exploration of pedagogical problems and engagement in reflection and critical analyses of teaching (Ball & Cohen, 1999; Putnam & Borko, 2000). Drawing on the work of Dewey (1965), Grossman and McDonald (2008) argue that pedagogies in teacher education need to approximate practice in such a way that prospective teachers should engage in “intensive, focused opportunities to experiment with aspects of practice and then learn from that experience” (p. 189–190). They suggest looking back and rethinking approaches such as microteaching in order to create experiences where what is simplified are not the very features of teaching that make it difficult.

One pedagogical approach that possibly meets these recommendations is Microteaching Lesson Study [MLS], an approach drawing on elements of microteaching and Japanese lesson study (Fernandez, 2005). MLS situates prospective teachers’ learning in practice within a simplified context, operationalising a cyclic collaborative process of development, implementation, analyses and revision akin to that of lesson study (Lewis, 2002; Lewis, Perry, & Murata, 2006; Stigler & Hiebert, 1999). Research on lesson study and its adaptations across settings for promoting teacher development (e.g., MLS) are needed (Lewis et al., 2006). The present MLS implementation and research were conducted to investigate the following questions: (1) How do prospective teachers learn about teaching through MLS, including what practices of the teaching discipline and aspects of MLS support their learning? (2) What do prospective teachers learn through MLS?

2. Related literature

2.1. Lesson study, microteaching, and MLS
Lesson study is a form of professional development highly valued among Japanese teachers (Lewis, 2002; Lewis et al., 2006; Stigler & Hiebert, 1999). The lesson study process brings a group of teachers together to collaboratively design and investigate a ‘research lesson’ developed to meet a specified overarching student-learning goal (Fernandez, 2002; Fernandez, Cannon, & Chokshi, 2003; Lewis, 2002). It includes cycles composed of several phases: collaborative planning, lesson observation by colleagues and other knowledgeable advisors, analytic reflection, and ongoing revision (Lewis, 2002; Stigler & Hiebert, 1999). As part of the process, lesson study groups develop a written reflective report of their work (Fernandez, 2002; Lewis, 2002).
MLS is a pedagogical approach incorporating the collaborative, continuous improvement aspects of lesson study and the simplified environment associated with microteaching. (see Table 1 for design elements corresponding to MLS, lesson study, and microteaching.) Design elements of MLS aligned with those of lesson study include the selection and operationalising of the particularly important overarching student-learning goal, the cyclic phases of the lesson study process including participation of a knowledgeable advisor, and the production of a group written reflective report. With respect to the overarching goal, in Japan, education officials, administrators or teachers propose the overarching student-learning goal for a lesson study (Lewis et al., 2006). For MLS, a teacher educator or instructor may propose this goal. With respect to participation of a knowledgeable advisor, Fernandez et al. (2003) recommended that such advisors were important in helping U.S. teachers look at their research lessons through critical lenses important to the lesson study process. For MLS, a teacher educator or instructor may assume this role, observing and watching videotapes of MLS lessons in preparation to meet with each group during some of the discussions of their lessons.

In addition to lesson study elements, MLS draws on elements attributed to microteaching. Similar to typical microteaching experiences (Benton-Kupper, 2001; Cruickshank & Metcalf, 1990; Grossman, 2005), MLS involves teaching that is simplified by class size (e.g., 5–10 students or student-peers) and lesson length (e.g., 30 min). The lesson length, however, tends to be longer than traditional microteaching experiences where lessons are typically 5–20 min in length (Cruickshank & Metcalf, 1990; Grossman, 2005). Additionally, MLS lessons are videotaped. This is not a norm for microteaching but is valued for providing a more complete record of the lessons for the prospective teachers to reflect on (Benton-Kupper, 2001; Kpanja, 2001). Given the reduced class size, the videotape can capture key interactions taking place within the lesson.

Different from microteaching norms is that the complexity of the content tasks for MLS lessons is not simplified and the focus of the experience is not on demonstrating any one particular teaching skill (i.e., using wait time, asking follow-up questions, providing clear directions, etc.), as are often the case for microteaching (Benton-Kupper, 2001; Cruickshank & Metcalf, 1990; Grossman, 2005). The content for MLS lessons is selected purposely in order for the students or student-peers being taught to lack knowledge of the content. By selecting the content in this way, the prospective teachers are able to navigate the complexities of authentically teaching content to students within a simplified setting. Another difference between MLS and microteaching is that microteaching experiences have traditionally been individual in nature for the one teaching (Cruickshank & Metcalf, 1990; Grossman, 2005) while MLS is collaborative.

### 2.2. Perspectives on learning for teacher education

In recent years, discussions of the nature of cognition and learning have provided increased attention to ‘situated knowledge’ or the ‘situative perspective’ as an important paradigm for student learning (Brown, Collins, & Duguid, 1989; Leinhardt, 1988). This theory underscores the integral nature of activity and situation to learning. Considering tools as a metaphor for knowledge in a discussion of situated cognition, Brown et al. (1989) stated, “People who use tools actively rather than just acquire them, by contrast build an increasingly rich implicit understanding of the worlds in which they use the tools and of the tools themselves” (p. 33). From this perspective, learning is in large part a process of enculturating wherein students learn to use tools as practitioners use them. The situative perspective, however, has not been sufficiently associated with the learning of teachers (Putnam & Borko, 2000). Consistent with the situative perspective is the formation of authentic instructional tasks. For teacher candidates, authentic tasks require activity that is faithful to professional practice (Iverson, Lewis, & Talbort III, 2008) and situated experiences have been defined as ones that foster the kinds of thinking and problem solving important to teaching (Putnam & Borko, 2000). Given these characteristics, fostering reflection as part of planning and implementing lessons would seemingly be deemed a valuable feature of situated experiences and authentic tasks for prospective teachers.

Reflection is an important process for teachers’ learning in and management of the demands of practise (Schon, 1987). It can support teachers’ problem solving, self-assessment, and continued growth in teaching. Many instructors have changed their approach to teaching after reflecting on how their students failed to understand seemingly obvious (to the expert) ideas (CBSSE, 2000). According to Jaworski (1998), reflective practise in teaching helps make explicit “teaching approaches and processes so that they can become the objects of critical scrutiny” (p. 7). This conception of reflective practice is aligned with Schon’s (1983, 1987) notion of reflective practitioner as a way for individuals to continue learning.

### Table 1

<table>
<thead>
<tr>
<th>MLS</th>
<th>Microteaching</th>
<th>Lesson study</th>
</tr>
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<tbody>
<tr>
<td>Lesson content</td>
<td>Overarching student-learning goal, selected purposefully for prospective teacher development</td>
<td>Reduced complexity of content to be learned</td>
</tr>
<tr>
<td>Focus on student learning related to actual teaching</td>
<td>Focus on teacher practising a teaching skill</td>
<td>Focus on student learning related to actual teaching</td>
</tr>
<tr>
<td>Structure of experience</td>
<td>Repeated cycles of planning, implementation, analysis, revision</td>
<td>Planning, teaching, analysis</td>
</tr>
<tr>
<td>Collaboration among MLS group</td>
<td>Individual</td>
<td>Collaboration among lesson study group</td>
</tr>
<tr>
<td>Forms of feedback</td>
<td>Instructor is knowledgeable advisor</td>
<td>Mentor or instructor</td>
</tr>
<tr>
<td>Feedback from peers in MLS group</td>
<td>Feedback from student-peers taught, optional</td>
<td>Feedback from peers and others invited to lesson presentation</td>
</tr>
<tr>
<td>Videotape of lesson required</td>
<td>Videotape of lesson, optional</td>
<td>Videotape of lesson, optional</td>
</tr>
<tr>
<td>Implementation setting</td>
<td>Reduced class size sufficient for group work (5–10 students or student-peers)*</td>
<td>Reduced class size (e.g., 5–10 students or student-peers)</td>
</tr>
<tr>
<td>Reduced lesson length (at least approx. 30 min)</td>
<td>Reduced lesson length (5–20 min)</td>
<td>Usual lesson length</td>
</tr>
<tr>
<td>Products</td>
<td>Written reflective report and lesson plans to be shared</td>
<td>No requirement of written report</td>
</tr>
</tbody>
</table>

* In the present study, the MLS involved student-peers.
in practise. A product of the reflective process important to indi-
viduals' learning is awareness of what one is doing and why, in
essence connecting practise and theory, respectively (Schon, 1983,
1987). For prospective teachers, the reflective process may conse-
quently be important for their development in practise of peda-
gogical content knowledge that is aligned with recent reforms and
theories of teaching and learning.

Pedagogical content knowledge carries particular importance in
the learning of prospective teachers and therefore should be
attended to in the construction of learning opportunities for these
novices. This type of knowledge for teaching content is distinct
from knowing the content. According to Shulman (1986), peda-
gogical content knowledge refers to the “ways of representing and
formulating the subject that make it comprehensible to others”
(p. 9). Graeber (1999) expanded Shulman’s (1986) conception of
pedagogical content knowledge to include knowledge of ways of
“eliciting from students various approaches to justifying a claim or
understanding a concept” (Graeber, 1999, p. 192). Such a conception
supports more student-centred teaching. For mathematics
teachers, pedagogical content knowledge aligned with this notion
may include ways of bringing about students’ mathematical
reasoning in making conjectures and developing generalizations, as
well as defending and verifying these, important for mathematics
student learning (AAMT, 2002; NCTM, 1991, 2000). Similarly, for
science teachers, it may include ways of bringing about students’
scientific reasoning and critical thinking in asking questions,
making, investigating, and explaining or rejecting hypotheses,
communicating scientific arguments, and developing an under-
standing of and disposition toward scientific inquiry, a goal for
science student learning (National Research Council, 1996). Also, for
English language arts teachers a related goal for student learning
may include ways of bringing about students’ questioning, brain-
storming, hypothesizing, imagining and reflecting in support of their
literary analysis of texts in the development of arguments and
understanding about recurrent patterns and themes and authors’
uses of literary features to achieve their purposes (International
Reading Association & National Council of Teachers of English, IRA
& NCTE, 1996).

3. Contextualizing the present MLS experience

The present MLS took place in an initial course on learning to
teach for prospective secondary school mathematics teachers. The
participants in the course included 18 prospective teachers ages
20–25 years old. Prior to the MLS experience, the prospective
teachers discussed readings and analysed videotaped lessons to
develop their understanding of recent reforms in mathematics
education. Additionally, the prospective teachers participated in
activities and discussed written lessons that modelled the current
vision of teaching mathematics, including tasks involving exploring
examples and/or non-examples, constructing/conjecturing
concepts or relationships, discussing constructed definitions or
conjectures, and defending mathematics relationships and
concepts (AAMT, 2002; NCTM, 1991, 2000). As part of these expe-
riences, the prospective teachers worked in cooperative groups and
discussed expectations for effective participation in cooperative
learning activities.

The MLS involved cooperative groups of prospective teachers
planning, analysing, reflecting on, and revising research lessons
taught to their student-peers. In arranging the MLS experience, I
selected secondary school mathematics content for which the
prospective teachers lacked familiarity or understanding as deter-
mined from an initial survey. In this way, the MLS group members
would authentically teach mathematics to their student-peers. This
also meant the MLS teachers needed to learn or re-learn the
mathematics they were teaching, a situation familiar to many
novice teachers with whom I work. The information gathered
through initial surveys and my observations about the individual
participants (e.g., academic progress in the course, interactions
with others, observed mathematical ability, and perceptions about
teaching mathematics) guided my creation of six heterogeneous
MLS groups each consisting of three prospective teachers. The
mathematical concepts or relationships they were to teach
included fractals, traceable paths, Euler’s formula, permutations,
prisms and pyramids, and ellipses.

As part of the present MLS, I, as course instructor, proposed an
overarching process-learning goal for the MLS research lessons. The
selected goal for the lessons was to develop students’ mathematical
reasoning and ability to study patterns in discovering relationships
or constructing concepts through experimenting, analysing,
conjecturing, and defending or justifying mathematical ideas. I
chose this goal because over time I have observed that the US
prospective teachers with whom I work experience difficulty
developing or implementing lessons or tasks with this goal. Addi-
tionally, research involving practising teachers has revealed US
teachers lacking in this area. The TIMSS 1995 and 1999 Video
Studies revealed that US teachers were not engaging their
secondary mathematics students in reasoning mathematically as
recommended in recent reforms (Jacobs et al., 2006). Fernández
and Cannon (2005) found that in contrast to Japanese teachers, for
practising US teachers, the goal of teaching specific mathematics
content “took precedence over ensuring that students acquired this
content through a particular learning process (i.e., one that
involved student discovery and control versus greater teacher
control and directiveness)” (p. 494).

As part of the MLS research investigation, the week before the
MLS experience, I gathered pre-MLS data in the form of individual
lesson plans created by the prospective teachers to teach students
about odd and even functions. I gave each participant a copy of
a traditional textbook section on the topic and asked them to create
a lesson plan consisting of the same overarching goal as that for the
upcoming MLS lessons. At the end of the MLS, the prospective
teachers were asked to revise and submit a post-MLS lesson plan
once again on odd and even functions.

The MLS was implemented over four weeks during the second
half of a semester-long course. During the first week, I gave each
MLS group copies of a textbook section containing their assigned
concept or relationship from a traditional mathematics text on the
state adoption list and allowed the groups to discuss, research, and
develop their initial MLS lesson plans. Over the next three weeks,
repeated MLS teaching cycles were carried out, including one
teaching day (class period) per week with analyses and revisions
occurring during the intervening weeks from one teaching day to
the next. For the teaching days, I assigned each MLS group member
to a different small class of six student-peers that met in three
different but reasonably close locations. Each of the six MLS lessons
(approximately 30 min each) was taught in one of the small classes
during each teaching day in such a way that two different MLS
lessons were taught in each class. Over the three weeks, each MLS
group member taught once within his or her assigned small class.
Each lesson was videotaped so all members of an MLS group could
collaborate on reviewing, analysing, and revising the lesson plan for
re-teaching the following teaching day.

Central to the experience, each MLS group completed a written
reflective report of their work. This report consisted of five parts
that guided their group through the phases of the MLS. Part 1
included pre-lesson thoughts, materials, and the lesson plan. Part 2
included analysis of the first teaching of the lesson in the form of
individual and group reflections, videotape of the lesson, and
revisions to the lesson plan. Part 3 included analysis of the second
teaching of the lesson (individual and group reflections), videotape of the lesson, and revisions to the plan. Part 4 included analysis of the third teaching of the lesson (individual and group reflections), videotape of the lesson, and final revisions. Part 5 included the final revised lesson along with suggestions for teaching the lesson to be distributed to class members.

During the phases of the experience, MLS lessons were videotaped and group discussions were audiotaped. As a knowledgeable advisor, I observed and watched videotapes of the MLS lessons and interacted with the MLS groups in and out of class, sometimes providing written questions for the groups to consider. I formally meet with each MLS group once during a group discussion following their first or second teaching. My communications with the groups primarily involved exchanges related to the pedagogy and mathematics of their lessons. Typically, I posed questions to challenge the MLS groups’ thinking about the teaching, learning, and mathematics of their lessons.

As course instructor, on occasion, I engaged MLS group members in brief discussions about their group cooperation in order to support their efforts to cooperate effectively. Also, I gathered individual feedback at the end on their perceptions of and learning through the MLS and how each group member contributed to their MLS group goal. In these ways, I sought to maintain individual and group accountability for their group cooperation (Johnson, Johnson, & Holubec, 1994).

4. Method of inquiry

The mode of inquiry I employed was interpretive case study (Merriam, 1988). This mode of research involves the gathering of extensive data with the intent to interpret or theorize about a phenomenon. All 18 prospective teachers enrolled in an initial course on learning to teach mathematics agreed to participate. Data collection included individual pre- and post-MLS lesson plans, MLS group written reflective reports, videotapes of the MLS lessons, field notes from the phases of MLS, transcripts of audiotaped MLS group meetings throughout the cycles, and MLS feedback surveys. The multiple data sources were used to triangulate the findings (Patton, 2002).

The analysis of the data occurred over several phases. The first phase began with segmenting and coding of the participants’ lesson plan procedures. I drew on existing literature on mathematics teaching (NCTM, 1991, 2000) as a lens for developing codes grounded in the lesson plan procedures. Through this process, I composed the coding scheme for the lesson plan procedures found in Table 2. The second phase of analysis consisted of applying the coding scheme to all of the pre- and post-MLS lesson plans, as well as the group MLS lesson plans. I used the coding scheme to segment and code the procedures in each of the lesson plans. A second mathematics educator used the coding scheme to analyse the procedures of a randomly selected set of the lesson plans with no

<table>
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<tr>
<th>Component</th>
<th>Examples from lesson plans</th>
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<tbody>
<tr>
<td>Introductory teacher posed prior knowledge related question or task</td>
<td>First, ask the students what they think a polyhedron looks like. Either ask them to come up and draw one on the board, or simply describe it so that the teacher might draw one.</td>
</tr>
<tr>
<td>Introductory teacher posed current topic related problem or task</td>
<td>Introduce students to the ‘barnyard’ problem by seeing if they can trace the figure without lifting their pencil or overlapping any of the edges.</td>
</tr>
<tr>
<td>Teacher tells/states relationship(s) or definition(s)/defining properties</td>
<td>Teacher informs students of definition of even function: a function is an even function when ( f(x) = f(-x) ) for all ( x ) in the domain of ( f ). This is symmetric with respect to the ( y )-axis. An odd function is when ( f(x) = -f(-x) ) for all ( x ) in the domain of ( f ). This is symmetric with respect to the origin.</td>
</tr>
<tr>
<td>Teacher directs examining, analysing examples and/or non-examples, and constructing of relationships or defining properties</td>
<td>A three-dimensional view of a tetrahedron will be drawn on the board. Students will be asked to make a tetrahedron with the toothpicks and gumdrops. While they are doing this, the teacher will write related terms on the board. The teacher will explain the terms and as a class fill in the chart (vertices, faces, edges). Then a cube will be drawn on the board. The teacher will help the students uncover the relationship between the number of edges, faces and vertices: Euler’s Theorem.</td>
</tr>
<tr>
<td>Teacher defends, justifies or disproves conjectures, relationships, defining properties, or examples/non-examples</td>
<td>*Show the students how the two permutation formulas are related. Explain why the ( nPr ) formula for ( n ) objects taken ( r ) at a time can be deduced from the ( nPr ) formula for ( n ) objects taken ( n ) at a time by dividing by the factorial of ( n - r ), that is the number permutations for the objects not selected: ( nPr = \frac{n!}{(n-r)!} ). The teacher will ask the groups to create an example and non-example of a traceable circuit and encourage the groups to explain why a traceable circuit has at most 0 or 2 odd vertices.</td>
</tr>
<tr>
<td>Teacher directs application of relationship or defining properties/definition(s)</td>
<td>After the activity, explain the three properties of fractals. Also offer a definition. Display various pictures of different fractals. Explain why each is a fractal.</td>
</tr>
<tr>
<td>Teacher facilitates class discussion of student generated observations, relationships, defining properties</td>
<td>*After working in their small groups, the students are brought together, and a whole-class discussion begins. The discussion focuses on each group’s idea of the relationship between the graph and equation. After each group shares and the class discusses the ideas presented, the class comes up with a relationship that the majority agrees upon.</td>
</tr>
<tr>
<td>Students explore, examine, analyze examples and/or non-examples posing conjectures, constructing relationships or defining properties/definition(s)</td>
<td>The students, in their groups, will be given a handout of assorted functions sorted into three groups. They will include functions that are odd, even, and neither (although these names need not necessarily be given). The students will be asked to determine criteria that define the functions in each group.</td>
</tr>
<tr>
<td>Students defend, justify or disprove conjectures, relationships, defining properties, or student created ex(s) and non-ex(s)</td>
<td>The teacher will ask the groups to create an example and non-example of a traceable circuit and encourage the groups to explain why a traceable circuit has at most 0 or 2 odd vertices.</td>
</tr>
<tr>
<td>Students apply relationship(s), defining properties/definition(s)</td>
<td>Present the following question for the class to solve: American Idol has 10 finalists on a traveling tour. Suppose they sing in a different order each night. How many nights can they go without repeating the order?</td>
</tr>
</tbody>
</table>
identifying features of pre, post, or group lesson. Inter-coder reliability on the randomly selected lesson plans was 96%.

During the third phase, I used open coding to segment and assign codes to the transcripts of the MLS group discussions, the MLS group reflective reports, and field notes. I triangulated the multiple data sources and used selective coding to develop themes for grouping the segmented and coded data. An example of a theme was ‘Understanding subject-matter for teaching students.’ This theme encompassed data segmented and coded as follows: “focusing on the textbook section as the authority;” ‘clarifying own understanding of different representations, examples, and non-examples;’ ‘examining language in communicating mathematically;’ and ‘defending or disproving mathematical conjectures and ideas.’ Then in the fourth phase, the feedback surveys were analysed and used to triangulate the participants’ perspectives about MLS with the emerging findings from the other analyses.

5. Findings

In the text, I have organized the findings from the MLS case into sections representing the predominant themes related to typical practises of the teaching discipline that the prospective teachers entered as part of their experience. The findings reported in these sections reveal elements of how and what the prospective teachers were learning through engagement in these teaching practises. I begin by presenting changes found in the procedure components of their individual pre- and post-MLS lesson plans. Then I discuss findings grounded in the MLS cycles in which they taught their group lesson.

5.1. Changing teaching approaches from pre- to post-MLS lesson plans

Fig. 1 contains a graph representing the landscape of procedure component types (see Table 2) found across class members’ individual pre- and post-MLS lesson plans. The graph makes evident the changes that occurred. The pre-MLS lesson plans included more teacher-centred procedures. These plans included primarily teacher telling or stating and teacher directing the exploration and construction of concepts or relationships, and teachers’ application of the mathematics ideas followed by student application. The post-MLS lesson plans tended to include more student-centred procedures. These plans included students exploring mathematical ideas, making conjectures, and engaging in reasoning processes aligned with the overarching learning goal for the lessons, and the teacher acting as facilitator of class discussions. This comparison revealed growth in the prospective teachers’ understanding and ability to envision and construct lesson plans that were better aligned with recent reforms (AAMT, 2002; NCTM, 1991, 2000). At the end of the MLS, on their feedback surveys, the prospective teachers acknowledged this growth. They reported comments such as “This [MLS] process has helped me to apply what we have been learning about in class. I now have a much better understanding of how to actually TEACH a lesson to a class where students develop a relationship.”

5.2. Aligning lesson procedures with an overarching process-learning goal

The MLS group members were challenged by the need to develop lesson procedures that were aligned with the proposed overarching process-learning goal. When planning their lessons for the first teaching cycle, their conversations often veered toward the idea of the teacher imparting the content to their students. The following excerpt is from one of the permutations group’s planning sessions for the first MLS teaching cycle. (PT1, PT2 and PT3 are pseudonyms for the permutations group members, corresponding to the MLS cycles in which they taught their group lesson.)

PT1: All of this is the formula here. [Looking at textbook section.] How should we introduce it?
PT2: What about these examples? We can use an example to show the formula.
PT3: Yeah, like we can show them 9% and then we can show them one of these where they have to apply it to a real world situation.
PT1: Is there some activity we can use?
PT3: What do you mean?
PT1: Like instead of just putting an example on the board, can we use a hands-on example to show the formula?
PT2: What about the lottery? We can bring in Lotto cards [Forms used in the state lottery].
PT1: How about musical chairs? How many ways can three people sit in three chairs?
PT3: I like that.

The MLS groups, as in this excerpt from the permutations group, tended to seek real world or hands-on examples for teaching their lessons, an idea associated with recent reforms (AAMT, 2002; NCTM, 1991, 2000). However, they initially tended to view these examples as tools for showing, telling, or demonstrating their MLS
concepts (e.g., definitions) or relationships (e.g., formulas) to their students and as sources for motivating student interest, rather than as sources for students to explore and construct the relationships and concepts through their own experimentation and mathematical reasoning.

Analysis of the data gathered across the MLS cycles revealed incremental growth in prospective teacher thinking of ways to meet the overarching student-learning goal. With each cycle, the MLS groups were able to trial, deliberate and make adjustments to their lessons. Throughout the cycles, in my role as knowledgeable advisor, I often asked questions that drew the prospective teachers’ attention to how their students were meeting the overarching process-learning goal. The prospective teachers reported that my interactions with them were helpful in revising their lessons. On the MLS feedback surveys, most made comments as follows as a response to the instructor feedback: “It raised more questions about how we were teaching and how to look at what to change; It was very helpful in analysis of our lesson implementation and the following lesson draft.” The following excerpt from a discussion with the permutations group after their first teaching is one of many representing my questioning in MLS group discussions.

Author/Knowledgeable Advisor [AKA]: How were the students constructing the formula?
PT1: We are still not sure how to do that without showing them with an example.
PT2: Usually, I would just tell them the formula for permutations and go from there.
PT1: Maybe we can have them explore an example of permutations and see what they discover?

My question to the group revealed a tension, observed across the MLS groups, between the prospective teachers’ prior personal knowledge about teaching mathematics by “showing” and their present learning about ways of teaching mathematics where students “explore” and “discover,” an approach aligned with the proposed overarching learning goal. The prospective teachers exposed and reconsidered their prior knowledge about teaching as they searched for new ways of teaching their MLS lessons. As the groups progressed through the MLS cycles, they increased the alignment of their lessons with the overarching learning goal. The cycles provided an avenue through which their lessons evolved toward more student-centred lessons including procedures that involved more teacher facilitation and elicitation of students’ reasoning to explore, construct, and defend the concepts and relationships being learned (see Fig. 2).

5.3. Developing approaches to teaching content in response to student learning

Fig. 2 presents a graph demonstrating changes in the procedures of group lesson plans across the three MLS cycles, beginning with lessons composed of more teacher-centred procedures and ending with lessons consisting of more student-centred procedures. This transition in their lessons was not an easy one for the prospective teachers. It was riddled, in ways, with the challenge of envisioning mathematics teaching in a manner different from what they were typically accustomed to.

As the prospective teachers participated in their MLS group discussions (with and without my participation), many expressed personal knowledge about the teachers’ roles in lessons as one of informer and transmitter of knowledge. PT2’s comments in excerpts from Section 5.2 reveal such views. Some prospective teachers expressed personal views about students’ abilities that might impede their capacity to teach in ways that foster students’ exploration and construction of relationships or concepts for themselves. For example, during the first MLS cycle, PT3 commented in a group discussion: “There is no way they are going to be able to tell us the formula” [italics added for emphasis]. Working individually this view might have obstructed PT3’s thinking about teaching ideas that might foster students’ construction of a permutation formula for themselves. However, given the MLS group structure, PT1 countered, “Well, we can have them try and explore and see what they discover.” Overwhelmingly, on the feedback surveys, the prospective teachers reported the importance of their collaboration in providing alternate ideas and helping them to see things differently, as captured in the following response: “They were able to provide methods that I wasn’t able to think of, which actually helped me think of other possible methods; Sometimes you feel like a certain method would work the best, but then a different approach could make you see things in a different light.” To a lesser extent, some also expressed that participating as students in others’ lessons helped them think more deeply about their lessons, as in the following comment: “Seeing the variety of teaching showed that many things can be taught many ways—more than just stating it, practising it and testing on it. They were creative and fun; And made you actually learn the material rather than just memorize it.”

As the prospective teachers implemented their MLS group lessons and collaboratively analysed their students’ learning and behaviours relative to their teaching and intended student learning, they modified their lessons, exploring different practises and teaching approaches. Progressively their lessons became more centred on
elicitings students’ reasoning, exploration, and construction of the mathematical ideas. Initially, the prospective teachers tended to demonstrate one or two examples (with differing levels of computational complexity) followed by the teacher stating the relationship or properties of the concept (or vice versa) and then showing the students how to apply the ideas. For example, in their first MLS lesson, the permutations group decided to begin their lesson by modelling a “musical chairs” example and then explaining through a tree diagram strategy “How many ways can 3 people sit in three chairs?” This was followed by showing “How many ways can 4 people sit in four chairs?” to demonstrate the relationship $P = 4 \times 3 \times 2 \times 1$ and introduce a corresponding permutations formula (i.e., $nPr = n!/(n-r)!$). Then they used the state lottery example to present a second formula for determining the number of permutations for six Lotto numbers out of 52 (i.e., $nPn = n!/(n-r)!$).

When the permutations group discussed the students’ learning and behaviours within their first lesson, PT1 suggested they engage the students in exploring and solving the given examples or problems for themselves. This produced in their MLS group a reframing of their lesson. The prospective teachers began to think of how to engage the students in exploring and generating the formula for themselves. For the second lesson, the permutations group decided to use the same examples as in the first; however, this time the students where to construct a permutations relationship through their own experimentation. Based on the teaching of the second lesson, they found that these examples did not suffice for students to construct a permutation relationship for themselves. In fact, the lottery example confused the students because in the real world the state Lotto was an example of combinations, where order does not matter, rather than permutations, where order matters.

Based on observations of their students’ learning during their implemented lessons and, in part, their involvement as students in other’s lessons, the MLS groups could see differently and reframe the examples, problems, and tasks they used for their lessons. They saw that the very limited number of examples presented in the more teacher-centred lessons was not sufficient for students to construct the desired relationship or concept for themselves without the teacher showing it to them. For the permutations group, this reframing heightened their awareness of the choice of mathematical examples or questions for teaching more student-centred lessons. The following exchange occurred at the end of the second cycle while the permutations group was reflecting on the second teaching of their lesson. It illustrates an intended change for their third lesson revision, based on their reframing, to create a more effective student-centred lesson.

PT1: The discovery of the relationship was directed more by the teacher than the students. How can we get the students to lead the discovery?
PT2: Could we pose more real world problems?
PT3: What about the baseball problem? Nine players, how many different batting orders?
AKA: How will you use that problem for the students to discover the relationship rather than the teacher?
PT3: Could we break it down? How many batting orders for one player? How many for two players? Three players? Four players?
PT1: Yeah. They could look for a pattern.

In their third lesson, the permutations group posed the following problem for students to explore and create a permutations relationships in small groups:

(A) There are nine players on a baseball team. How many different batting orders of nine players can the coach make? Look for a pattern to determine your solution. How many different batting orders for one player if there was only one player? Two players if there were only two players? Three players if their were only three players? and so on. Make a table. Explain your solution.

(B) There are 12 players on a softball team. How many different batting orders of nine batters can the coach make?

After the students constructed their permutations relationships with their partners and discussed them as a class, the teacher introduced them to mathematical notation for recording the relationship or formula (i.e., $nPr = n!/(n-r)!$ or $nPn = n!$).

As part of the MLS written reflective report, the prospective teachers recounted struggling with “deciding which problems would be more beneficial for the students to explore and to make sure there were enough examples.” They began to understand that students would need to examine patterns based on a greater quantity and variety of examples and/or non-examples that incorporated different possible cases or critical characteristics of the mathematical idea, in order to create for themselves the desired mathematical relationships or concepts. Participating in the MLS cycles supported the prospective teachers’ reflecting on and incrementally revising approaches to teaching their MLS lessons in ways that helped them begin to rethink their ideas and knowledge about teaching and learning in light of practise. The permutations group commented as follows in their written reflective report:

“We learned how important it is for students to take an active role in their learning, and have time to explore and conjecture with one another, in order to grow as mathematical thinkers and develop important skills such as problem solving, reasoning, and mathematical communication with one another.”

5.4. Exploring, analysing, and making curricular choices for teaching

As the prospective teachers participated in the MLS experience, they sought, analysed, and drew on a variety of instructional materials and tools for teaching their assigned mathematical ideas. As reported earlier, they often began looking for hands-on activities or real-world examples to motivate student interest and apply the mathematics ideas. One such example is the musical chairs idea discussed and modified by the permutations group for introducing their lesson.

In addition to copies of the textbook section given to each MLS group, the prospective teachers explored internet resources, teacher resource books, and additional mathematics textbooks looking for teaching ideas and ways to more thoroughly understand the mathematics concepts they were expected to teach. As a knowledgeable advisor, I offered suggestions where appropriate. The permutations group came across the idea for the baseball batting order problem discussed above while exploring the Math Forum website I recommended (http://mathforum.org/dr.math/).

The MLS groups used textbook resources to help them reflect on and make curricular decisions related to what the students would have learned prior to the given lesson and what they might learn afterward. For example, the permutations group found that the concept following permutations would likely be combinations. Armed with this understanding, they noted in their written reflective report a change in their language use: “When discussing permutations we should not refer to them as combinations. Combinations will be discussed in a future lesson.” They decided instead to use the term arrangements.

The MLS groups also used information from textbooks to consider alternatives and make curricular decisions about when to introduce mathematical conventions during their lessons. For instance, the permutations group found differences in textbooks with respect to the mathematics convention of factorial, i.e., $4! = 4 * 3 * 2 * 1 = 24$, finding that factorial was sometimes
introduced prior to the permutations section and other times within
the section. Initially, they proposed discussing factorial at the
beginning of the lesson. However, over the course of the MLS cycles,
as they reframed their lesson to involve more student exploration,
they settled on discussing factorial after the students explored the
baseball batting order problem as a way of representing the student
discovered relationship in a concise manner using mathematical
conventions. Such deliberations could help the prospective teachers
understand the need to question what they might have previously
considered an authority on the content (i.e., the curricular materials)
and adapt these to meet their goals for student learning.

5.5. Considering general pedagogy and classroom management
for student learning

Even though the prospective teachers were teaching their peers,
they found it important to consider general pedagogical issues and
classroom management during their lessons. Through teaching and
análising their initial lessons, the prospective teachers observed
students acting uninterested and bored, sitting apathetically and
not participating during the lesson, talking with other students in
ways that were unrelated to the lesson, and writing personal notes.
The videotaped lessons helped the teachers broaden their awareness
of what their students were doing during the lessons.

As the groups proceeded through the MLS cycles, they framed
and reframed their lessons in light of desired student behaviours
and engagement in the learning process. They drew on prior
knowledge of strategies from their experiences as mathematics
students, as well emerging knowledge of strategies discussed or
modelled during the present course on learning to teach. The
following is an excerpt related to classroom management that
occurred as the permutations group analysed and revised their first
lesson. The videotape of the lesson helped PT1, the teacher,
recognize that all the students were not paying attention, something
they had missed during the lesson.

PT1: When I was up there, I was doing more of a class assessment.
But, when I watched the video, I saw Debbie didn't do anything.
PT3: Yeah, but she never does anything.
PT1: But as a teacher, I should have been aware of this and
gotten her involved.
PT2: This is just an idea but my middle school teacher would
have board races. We could have two teams—girls against guys.
And a different pair could compete each time.
PT3: Okay.
AKA: What will the rest of the class be doing?
PT2: Watching.
AKA: How is this engaging all the students in mathematical
reasoning to construct the relationship?
PT1: We’ll have to think about that.
PT3: It’s more for practising.

In the first MLS cycles, this group like others tended to consider
remedying the problem of lack of student involvement by imple-
menting a strategy to manage the involvement without looking at it
through the lens of the overarching student learning. I posed questions
to redirect their attention to consider classroom management in
conjunction with tasks for achieving their overarching learning goal.

The need to foster more student involvement was discussed
across the MLS groups. One common solution was to call on
students randomly if the teacher wanted a variety of students
involved in the whole-class activities or discussions. Some used a
die to call on students or groups randomly, as was modelled in our
class. Although the prospective teachers were teaching a small class,
I encouraged them to design mathematics tasks for teaching an entire
class, including activities involving cooperative pairs or groups. These
tasks could support student learning while providing opportunities
for the prospective teachers to listen to their students’ discussions.

Designing and implementing cooperative learning tasks also
helped the prospective teachers develop basic yet often overlooked
strategies for promoting group and individual accountability in
cooperative groups (Johnson et al., 1994). During their initial
learning and teaching with cooperative groups or pairs, the prospective
teachers tended to address questions or student work with individual
students rather than addressing these with the entire group. Their
teaching actions were not supporting group interactions. Through
minor management changes in their teaching over the MLS cycles,
they recognized that approaching questions or student work to the
entire small group evidenced more interactions within groups. As
PT3 observed, “It was funny. Talking to them as a group, I saw more
talking between them.” They also learned that calling on group
members randomly during class discussions motivated more
cooperation than just waiting for any student in the class to share.

As the prospective teachers progressed through the MLS cycles,
they began to interweave classroom management processes such
as using cooperative learning more effectively with the desired
student learning, as discussed during the course. The following
exchange occurred during the permutation group’s planning for
their third teaching. At this point, they were thinking about student
involvement in relation to student learning through the batting
order problem they had developed.

PT3: Should they work independently [on the batting order
problem]?
PT1: I don’t know maybe pairs.
PT3: Why?
PT1: Well in pairs they can discuss the patterns they are finding.
Maybe one sees something another one doesn’t.
PT3: Okay. What if they work individually for 5 minutes and
then in pairs?
PT2: Why?
PT3: So each does their own work and then they can share.
PT1: Yeah, like in the Japanese video [TIMSS, 1995].

During the MLS cycles, the prospective teachers discussed
various general pedagogical issues within their groups. In addition
to student involvement, some discussed the use of appropriate wait
time after posing a question or asking students to complete a task.
For example, the permutations group commented in their reflective
report, “We noticed the importance of wait time. PT1 began talking
when the students were filling out the Lotto cards and so they
weren’t paying attention to him or to what any other students were
saying.” The groups also discussed ways of using the chalkboard,
overhead, or computer and LCD projector during their lessons. For
instance, the permutations group observed in their report, “We
decided we should list the arrangements on the board and leave
them there. This will make it easier to discuss the relationship as
a class.”

5.6. Understanding subject matter for teaching students

Recall that the MLS groups needed to learn or re-learn the
mathematics in order to teach their lessons. In planning to teach
the MLS lessons, the prospective teachers tended to focus initially on
the textbook section as the mathematics authority for their lessons.
They reviewed the section for teaching while at the same time using
it to learn the mathematics. The following is an example of this
interplay from an initial planning session of the permutations group:

PT3: So what are we supposed to do?
PT1: This is the formula here? [Looking at textbook section]
PT2: Yeah looks like.
PT1: We need to find a way to introduce this where they discover the formula.
PT3: Yeah.
PT1: This is permutations so order matters. [Looking in textbook section.]
PT2: It seems like examples here. So, we could show them one of these after we show them the formula.
PT3: According to this, the counting principle was in the last section.
PT1: I see how they came up with this formula. Given that you already know the counting principle.
PT3: Yeah. Use the counting principle to find the number of permutations, like here. [Looking at example in textbook section.]

Through the MLS cycles, the prospective teachers engaged in reasoning and problem solving that deepened their understanding of the relationships or concepts they were teaching. They sought and explored different representations, applications, examples and non-examples, expanding on or revising those used in their initial MLS lessons. For example, the MLS process helped the permutations group understand that the Lotto example was not appropriate as an example of a permutation (an arrangement where order matters) because in the real world it was actually an example of a combination (an arrangement where order of the selection of the six numbers on the Lotto form does not matter). After the second teaching, PT3 observed, “The students were confused with the lottery problem. They were saying they didn’t know what they were trying to find.” As they discussed why, I asked “Could the confusion be the Lotto example? Is it a permutation?” PT1 was the first to recognize the difficulty: “I see. Order doesn’t matter. It’s not a permutation.” The permutations group removed the Lotto example from their lesson and developed the batting order problem.

In addition to clarifying their understanding of the content throughout the MLS process, the prospective teachers recognized the importance of language in communicating mathematically with their students. As they analysed their lessons, they were able to observe points of student confusion, as well as areas needing further clarification. This process helped them begin to think more critically about the way they were using mathematical terms in their lessons. For example, the permutations group made the following comment in their reflective report:

We realized that we definitely need to be more aware of our use of vocabulary. One main weakness was our use of combinations when discussing permutations. This can be confusing. To fix this weakness, we are going to use the word ‘arrangements’ when referring to \( r \) in \( nPr \) instead of ‘combinations.’

Another mathematics issue that arose within MLS groups was the need for defending or justifying the mathematics relationships or concepts being taught. The need was sometimes triggered by questions from their students or by one of my questions. For example, asking “How are the formulas related?” at the end of their first lesson prompted the permutations group to add a teacher explanation of the relatedness and equivalence of the two formulas to their second lesson plan. Needing to defend or justify the constructed relationships or concepts precipitated further deepening of the prospective teachers’ understanding of the mathematics they were teaching.

6. Discussion

6.1. How the prospective teachers learned through MLS

6.1.1. Opportunities for authentic active learning
In the present study, MLS was shown to advance prospective teachers’ learning through opportunities to enter the culture of teaching in line with a situative perspective of learning (Brown et al., 1989; Putnam & Borko, 2000) and to engage in significant practises performed routinely by professionals, a feature of central importance for authentic tasks in teacher education (Iverson, Lewis, & Talbot, 2008). From this perspective, the findings reveal MLS to be an authentic task for teacher education. The prospective teachers actively engaged in important practises of the culture of teaching such as exploring changes in approaches to teaching in response to student learning of content; planning, implementing, and modifying lessons aligned with recent reforms; exploring and making curricular choices; purposefully interweaving processes for classroom management and student learning; and deepening teacher understanding of the content for teaching. It is reasonable to argue that prospective teachers participating in MLS in other content areas are likely to actively engage in similar relevant practises of the teaching discipline and, thus, similarly learn about teaching.

For the prospective teachers, MLS fostered active engagement in (1) practise and (2) planning, evidenced jointly in other teacher education tasks and experiences; however, it also fostered (3) meaningful discussions among them. Together these three activities characterize ‘active learning’ associated with the successful professional development of practising teachers, bearing significant positive effects on increases in teachers’ knowledge and skills and change in classroom practices (Garet, Porter, Desimone, Birman, & Yoon, 2001). Although teaching small classes of student-peers produces a simplified classroom environment, MLS sufficiently maintained important and authentic aspects of the complexity of typical classroom practise in order to help focus the prospective teachers’ attention on content pedagogy and the related student learning while engaging in managing classroom processes. Grossman and McDonald (2008) recommended studying teacher education pedagogies and experiences such as microteaching to understand ways of maintaining the complexities of the teaching discipline that make these teacher education. During the MLS, the student-peers were learning content that they were unfamiliar with or for which they lacked recall and understanding. Therefore, the MLS teachers needed to challenge their student-peers’ thinking, arouse their curiosity, and actively engage them in reasoning, as they might need to engage groups of secondary school students in any content area. When a lesson did not capture their student-peers’ interest or challenge their thinking or reasoning, the student-peers demonstrated off-task behaviour and lack of interest and involvement in the lessons. When the tasks were confusing with respect to the content (e.g., lottery example) or the directions and language were unclear (e.g., use of term ‘combinations’ for permutations), it was evident in the student-peers’ responses and participation (or lack of participation) in the lessons. Based on observations and discussions about their students’ participation and learning in practise, the prospective teachers were developing their knowledge and skills and revising their classroom practises, as evidenced through active learning in the professional development research (Garet et al., 2001). Thus, like active learning for practising teachers, MLS was shown to be a successful pedagogical approach for prospective teacher development and learning.

6.1.2. Opportunities to trial, analyse, rethink and adjust
Learning through MLS seemed to be particularly influenced by the opportunity for prospective teachers to trial, analyse, and adjust their lessons through the repeated cycles of MLS. From a situative perspective, through this aspect of MLS, the prospective teachers drew on and used their prior personal and emerging knowledge and skills as tools of the discipline to engage in common practises of the culture of teaching. Given their prior learning about teaching including experiences early in the present course, the prospective
teachers possessed an initial understanding of the teaching and learning aimed for (aligned with recent reforms, e.g., AAMT, 2002; NCTM, 2000), compared the actual teaching and learning in their lessons with what was being aimed for, and engaged in actions that helped close the gap between the two. These are three conditions thought to be of central importance for instructional tasks in teacher education that serve formative purposes for prospective teacher learning (Iverson, Lewis, & Talbot, 2008; Sadler, 1989). Within the MLS cycles, the prospective teachers revealed incremental changes in their understanding, construction, and use of tools (knowledge and skills) of the discipline aligned with recent reforms. Initially, their use of tools and understanding of the practises seemed to be superficial and lacking complexity, as in the case of teaching by teacher telling and showing the students a few examples. However, with each cycle, they seemed to gain a richer and more complex understanding of the practises and related knowledge and skills needed to foster students’ reasoning and construction of the relationships and concepts being taught. The recursive nature of the MLS allowed for formative feedback, as well as self-assessment, in conjunction with repeated opportunities for further action, each considered by Iverson et al. (2008) to be key criteria for high quality authentic tasks. Without the repeated cycles of implementation and revision complete with feedback and self-assessment within an authentically complex teaching context, the prospective teachers would arguably not have constructed their understanding of teaching concepts and relationships to the extent evidenced in the findings.

6.1.3. Reflection and collaborative deliberation-in-process

Throughout the repeated cycles, the reflection and collaborative deliberation that occurred appeared to be of particular importance for prospective teacher learning. The findings revealed that reflecting and deliberating on their MLS research lessons within their groups afforded the prospective teachers with opportunities to learn from considering alternate points of view to see differently and reframe events or problems within their lessons, which is consistent with prospective teachers’ perceptions of MLS reported by Fernandez and Robinson (2007). Through the collaborative MLS cycles, the prospective teachers repeatedly framed and reframed the problem of how to engage their students in reasoning to construct the desired relationships or concepts, considering alternate approaches in consultation with their peers and a knowledgeable advisor. In addition, the contrasting demand of participating as a student in other MLS group lessons, although having a seemingly more subtle influence on prospective teacher learning than their collaborative deliberation, provided opportunities for the prospective teachers to reflect on their MLS group lessons in relation to that of other MLS groups. According to Korthagen, Loughran, and Russell (2006), three principles that are fundamental for enhanced learning about teaching are (1) teachers’ research of their own practise as a catalyst for reflection, (2) close collaboration with peers, and (3) considering conflicting and competing demands evident in experiences where prospective teachers struggle to be both students learning content and teachers learning about teaching. In the present study, MLS encompassed all three.

The repeated reframing, adjusting and implementing throughout the MLS cycles engendered what might be thought of as ‘deliberation-in-process,’ a variation of Schon’s (1983) reflection-in-action that takes place within a group over an extended period of time. The MLS groups puzzled collaboratively over how to engage their students in constructing the desired relationships or concepts. The MLS experience provided a forum for the prospective teachers to expose and reconsider their personal knowledge about teaching and learning mathematics in light of practise and in collaboration with others. Thus, as the prospective teachers contributed ideas in their groups, others might raise an alternate point to consider. Then implementation of their lessons provided evidence of their group’s ideas in practise. The MLS cycles prompted them to think about their understanding of teaching of the content implicit in their lessons, analysing, restructuring, and embodying those understandings in their revised lessons (Schon, 1983). Through this process, the prospective teachers became better aware of what they were doing and why, an important product of reflection (Schon, 1983, 1987), and in this case deliberation-in-process.

6.1.4. Support from knowledgeable advisor

In addition to reflection and collaborative deliberation with peers, another aspect of MLS that evidently influenced the prospective teachers’ learning was the participation of the instructor as a knowledgeable advisor. According to Mason (1998), it is important for teacher educators to be aware of what teachers attend to during learning experiences. This awareness can arm us with new insights about teachers’ learning and, in turn, help us to design better teacher education experiences that focus their attention on what it is that they are intended to learn. Given that US secondary mathematics teachers lack teaching in ways that engage students in learning content through processes (e.g., reasoning, problem solving, representation, and so on) [Fernandez & Cannon, 2005; Jacobs et al., 2006], I purposely selected the overarching goal for the MLS to draw the prospective teachers’ attention toward engaging students in mathematics reasoning. Through the present MLS, the cycles provided repeated opportunities to focus the prospective teachers’ attention on developing and implementing lessons that engaged students in mathematics reasoning based on the overarching goal for the MLS lessons. During the planning and analysing phases, the MLS groups could discuss and repeatedly rethink their engagement of students in mathematics reasoning during the lessons. As a knowledgeable advisor for the MLS, my communications with the prospective teachers were often directed at drawing their attention to the overarching student process-learning goal and the observed student learning. The prospective teachers needed assistance in focusing on these central issues. Similarly, Fernandez et al. (2003) found that US teachers engaged in lesson study were assisted in attending to the overarching goal (i.e., “fostering students’ problem solving and responsibility for learning” (p. 174)) by the Japanese teachers participating in the lesson study as outside knowledgeable advisors. Without this outside support, the US teachers tended to lack discussion and analyses of their lessons with respect to the overarching goal.

6.2. What the prospective teachers learned related to teaching through MLS

Through the MLS process, the prospective teachers began to understand and practise how to foster students’ construction and learning of the content through a focus on a learning process (i.e., reasoning) rather than a focus on practising a skill. The prospective teachers developed pedagogical content knowledge aligned with this understanding (Graebner, 1999; Shulman, 1986). In the present study, the prospective teachers’ individual pre-MLS lessons and initial group MLS lessons tended toward teacher-centred procedures lacking alignment with the overarching process-learning goal. Initially when planning, most focused their attention on imparting content irrespective of fostering any learning processes (i.e., reasoning mathematically). Choosing some examples for telling the students the mathematical idea they were teaching was easier than thinking critically about tasks to promote students’ construction of the mathematical idea through their own exploration, analysis and reasoning. The latter teaching approach necessitated careful reasoning and analysis in the selection of the
However, formal research is needed to understand how prospective quadratic and exponential functions, and the discriminant for MLS lessons (i.e., prisms and pyramids, Euler’s Formula, and student teaching has revealed their drawing directly on some of the ways to improve the education of prospective teachers. Informal engage prospective teachers in meaningful discussion, planning, scores the merits of seeking pedagogical approaches that actively This investigation brought to light the prospective teachers’ initial understanding of the content (e.g., mathematics concepts and relationships) while at the same time learning about ways for teaching it. Mason (1998) argued the importance of teachers encountering unfamiliar generalities for themselves so that they can develop their own abilities to specialize, both in the content and in teaching of the content, “thereby enhancing their ability to know-to employ strategies with their students” (p. 249). During the present MLS, the prospective teachers found themselves needing to explore, analyze, and conjecture about patterns in examples and/or non-examples founding the construction of the mathematics generalities they were teaching. As they planned, analyzed and revised their lessons and participated as students in others’ lessons, they were also able to recognize patterns and develop generalities about teaching mathematics in ways that engaged students in mathematics reasoning.

Developing knowledge and skills of content-related instructional approaches, understanding of how students learn content through learning processes, and developing understanding of the content are all areas of in service teacher learning through lesson study (Lewis, Perry, & Hurd, 2004). The MLS also prompted teacher learning of general pedagogical practises and classroom management, as well as curricular resources. These are also areas of teacher learning through lesson study (Lewis et al., 2004). It seems reasonable to hypothesize that similarly implemented MLS experiences with prospective teachers in other content areas would result in their development of teacher knowledge in these same categories.

7. Final thoughts and future directions

For teacher educators, MLS seems to be a valuable teaching approach situated in practice through which we can engage prospective teachers in learning to teach during initial coursework. This investigation brought to light the prospective teachers’ initial focus on content irrespective of processes and thus the need to develop pedagogical approaches and experiences that focus their attention on learning processes (i.e., reasoning, problem solving, etc.) for promoting students’ understanding of content. It underscores the merits of seeking pedagogical approaches that actively engage prospective teachers in meaningful discussion, planning, and practice. Further development and research related to such pedagogical approaches and the extent of teachers’ use of knowledge and practises developed through these experiences in future classroom settings can further inform our continued pursuit of ways to improve the education of prospective teachers. Informal observations of some of the study participants as they completed student teaching has revealed their drawing directly on some of the MLS lessons (i.e., prisms and pyramids, Euler’s Formula, and ellipses) in their teaching, as well as drawing on the approach to teaching for mathematics reasoning that they learned (e.g., sum of the interior angles of a polygon, parabolas, transformations of quadratic and exponential functions, and the discriminants for quadratic functions). These informal observations are encouraging. However, formal research is needed to understand how prospective teachers draw on and implement knowledge and practises developed through MLS and other such teacher education coursework experiences in typical K-12 classroom settings.

References


