LESSON STUDY AS A SPRINGBOARD
FOR THE PROFESSIONAL DEVELOPMENT
OF MATHEMATICS TEACHERS

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Abstract

In Japan, Lesson Study (LS) has been used for many years as a way to connect teacher's learning with practice and to support professional development through teaching (Lewis, 2005; Lewis & Tsuchida, 1998; Stigler & Hiebert, 1999). During LS, teams of teachers meet regularly to work on the design, implementation, and improvement of one or several lessons. Members of the team plan the lesson. One member teaches the lesson, while fellow teachers observe and take notes on student learning. After the lesson, the team members reflect on the lesson, refine the lesson plan, and teach it again in a different class, accompanied again by observation and reflective discussion. The process is called a LS cycle.

For at least two decades researchers have called for systematic research of instructional improvement based on LS (Lewis, Perry & Murata, 2006; Puchner & Taylor, 2006; Stigler & Hibert, 1999). But despite extensive research on a variety of aspects of LS, identification of the knowledge types developed by teachers' participation in LS has not been sufficiently explored, and the mechanisms by which such knowledge develops have not been adequately analyzed.

Similarly to teacher educators in other countries, Israeli mathematics teacher educators have attempted to use the LS model to change mathematics teaching for the last several years. As teaching is a cultural activity, the implementation of LS in different countries requires examination and cultural adaptations (Davies & Dunnill, 2008; Perry & Lewis, 2008; Stigler & Hiebert, 1999). Mathematics teachers in Israel differ from their Japanese colleagues. Shared responsibility for lesson design and collaborative reflection on the lesson performance are typical of Japanese schools, but these practices are not part of the routine of Israeli teachers. Thus, the question of whether implementation of LS in Israel can contribute to changes in teachers' knowledge, beliefs, skills, and practices is important.

The present study aimed to explore *changes in the knowledge and practice* of elementary mathematics school teachers in Israel associated with their participation in LS, while tracing and analyzing the main *mechanisms* of these changes.

METHODOLOGY

In this study, two teams (Team A and Team B) of mathematics teachers from two elementary schools in Israel were involved in LS for one school year. In Team A there were 6 teachers, in Team B, 5 teachers. Participants joined the process as complete teams that included all the teachers who taught third to sixth grade mathematics in their schools. All agreed to participate in the LS process. All participants had more than five years of experience in teaching mathematics. Sixty-four percent had at least ten years of experience. The mean mathematics experience was 13.8 years for Team A and 12 years for Team B. All participants taught mathematics in at least two different grades during the research year. All the members of Team A had B.Ed. degrees (only four out of six specialized in teaching mathematics), whereas some of the members of Team B were certified only for lower grades, and only two out of five had studied mathematics.

Throughout the study, the two teams participated in three LS cycles, each containing the following stages: (1) planning a lesson collaboratively by the team; (2) teaching of the planned lesson by one teacher and observation by other team members; (3) reflecting on the lesson collaboratively to plan an improved version; (4) teaching of the improved lesson by one of the teachers and observation by the others; and (5) conducting a final reflective discussion collaboratively.

Overall, each team conducted 6 lessons and 9 team meetings in the course of the year. Additionally, each teacher was interviewed 4 times, once before each LS cycle and once at the end of the third cycle (a total of 44 individual interviews). The data were video-recorded, and artifacts, e.g., lesson plans and lesson observations recorded by teachers, were collected.

Data analysis covered the same elements that were part of the intervention: planning, reflecting, teaching, and individual interviews. Videotaped meetings, lessons, and interviews were transcribed. The data were analyzed by categories related to teachers' pedagogical knowledge and mathematics knowledge for teaching, as is customary in the relevant literature (Hill, Sleep, Lewis & Ball, 2007; Leikin, 2006, 2007; Shulman, 1986).

The study devised categories for the analysis of changes in teaching, the development of teacher knowledge, and changes in teachers' collaborative skills.

Changes in teaching were analyzed at two levels: macro-level analysis, dealing with lesson structure and lesson setting, and micro-level analysis, focusing on mathematical tasks and the quality of whole-class discussion, using the Initiations, Responses, and Evaluations (IRE) model (Cazden, 2001) (see Results in Chapters 1 and 2).

The development of teachers' knowledge was analyzed with reference to three types of knowledge: (1) knowledge about students' learning and thinking; (2) knowledge about ways of teaching; and (3) knowledge of mathematics for teaching (see Results in Chapter 3).

Changes in the teachers' collaborative skills were examined according to the following categories: (1) changes of teachers' terminology in meetings; (2) changes within the teachers' constructive team work; (3) changes in the teachers' readiness for action; and (4) changes from reluctance and fear toward LS to enthusiasm and acceptance. Content analysis of the data was performed according to categories related to changes in the focus of teachers' reflection in the course of the meetings (see Results in Chapter 4).

To explain some of the findings related to teacher's development as revealed in the above categories, the "Team Work of Elementary School Teachers" questionnaire was administered to 115 teachers (see Results in Chapter 5).

MAIN FINDINGS

Results are reported in five chapters, covering the following aspects: changes in teaching, changes of knowledge, changes in the nature of teachers' communication in the course of LS, and a description of Israeli elementary mathematics teachers' team work culture.

Changes in teaching (Chapters 1 and 2)

We identified changes in teaching by comparing two lessons in one LS cycle taught by the same teacher, and associated the mechanisms of the changes with the teachers' participation in the LS process.

Macro-analysis of the findings shows that the ***lesson structure*** of the two lessons differed in its time distribution. The time devoted to students' work almost doubled in the

improved lesson. Analysis of the findings, comparing all teachers and all lessons in all cycles, shows a similar direction of change within the lesson structure of the two teams, with increasing amounts of time devoted to students' independent work, which tended to become the central part of the lesson.

The findings concerning ***lesson setting*** (review, grouping, and active participation) show differences between the first lesson of the cycle and the improved lesson: In the improved lesson, the review of previous content was more conceptualized; teacher questions and student answers were longer, and contained more elaborate explanations; and teacher-student interactions were replaced by student-student interactions. The type of grouping changed to being more homogeneous, organized by achievement level. As a result of these changes, students became more active, and more students were able to cope with the tasks.

Micro-analysis of the two lessons in each cycle shows that the ***mathematical tasks*** were transformed to fit better the students' needs; the ***IRE structure*** of the whole-class discussion changed to devote more time to students' active work on mathematical tasks and to their participation.

Following the analysis of the findings, comparing all teachers and all lessons in all cycles, we identified five categories of changes in the ***mathematical tasks*** presented to the students: (a) elaboration of a task by a reflection question; (b) transforming a task in view of students' difficulties; (c) transforming a task according to the mathematical meaning of an algorithm; d) changing the complexity of tasks; and (e) transforming a task according to the levels of different students. All changes were the result of decisions taken at the planning and reflection sessions of the teams. All types of changes, within both teams, illustrate "new" teachers' focus on students' learning and thinking.

Referring to the ***IRE structure,*** the differences within the two teams refer to the entire time that the teacher led the discussion throughout the process, which reveals greater decrease in Team B than in Team A, while the time distribution of IRE actions between the two teams reveals that the direction of Initiations and Responses types of action were towards more Process and Meta-process teacher's Initiations and Responses, in Team B than in Team A, almost through the whole process.

Development of teachers' knowledge (Chapter 3)

Analysis of the teachers' knowledge during the LS process shows changes in teachers' knowledge in the areas of awareness of students' learning and thinking; recognition of the importance of defining a precise goal (agenda) for each lesson; and the skills required for noticing, understanding, and using students' reactions in teaching. These types of knowledge developed in almost all the participants. In addition, ten of the eleven teachers acquired knowledge of mathematics for teaching, including the use of relevant mathematical examples in teaching, focusing on mathematical meaning vs. procedures in presenting mathematical topics to students, and using systematic approaches to problem solving. We found no evidence of teachers' learning of subject matter knowledge of mathematics. Note that, one teacher, Ronnie, the only one unwilling to teach an observed lesson, was also the only teacher who showed no evidence of change.

Changes in the nature of teachers' communications (Chapter 4)

We identified four changes in the nature of teachers' communications during reflection meetings. First we found that teachers in both teams acquired a more collaborative terminology. For example, they changed their talk from "I", "you" and "she" to "we." Second, teachers who were initially judgmental of each other's work and decisions, changed toward the end of the research year into constructive and collaborative team members. Third, initially we recognized that the teachers used assertions ("big words") and general declarations about what needed to be done (e.g., improving students' number sense), without any of these issues appearing in lesson planning. This changed through the LS process into action and guidelines for doing (e.g., asking how to do things to advance students' learning). Fourth, the teachers changed their attitude from reluctance and fear toward the LS process, to acceptance and enthusiasm.

Three ***mechanisms*** of teacher learning in LS were identified in the course of the research:

1. Collaborative noticing,
2. Collaborative awareness,
3. Brainstorming.

Some elements of teacher's team work in Israeli elementary schools (Chapter 5)

We discussed the pitfalls encountered in implementing LS because of the school culture in Israel. A questionnaire administered to 115 elementary school teachers shows that teachers devote very little time during the week to lesson planning. More than half the teachers devote only 5 minutes to choosing the mathematical tasks for the lesson, and most of them never anticipate student reactions in planning. Moreover, only 10% of the teachers reported reflecting regularly on their teaching, and about 70% reported that they had never observed each other's lessons. Only 13% of the teachers reported attending weekly team meetings, at which most of them (about 80%) almost never plan lessons together with colleagues.

These characteristics demonstrate the starting point of the culture within which Team A and Team B is performed before their participation in LS.

CONTRIBUTIONS

In the ***theoretical dimension,*** the study contributes the notions of collaborative noticing, collaborative awareness, and brainstorming as the mechanisms of teachers' professional development through LS.

In the ***methodological dimension,*** the study devises tools that may be useful in research focusing on the professional development of mathematics teachers. Among these tools are the categories for the analysis of mathematics lessons and mathematical tasks. The study provides tools for the analysis of school culture associated with teachers' team work. It suggests that studies focusing on changes in teachers' practice should start with the identification of the conditions in which these changes take place.

In the ***practical dimension,*** the study is an "existence proof" of implementing LS in Israel, and as such it can serve as a model for teachers' training that supports the development of teachers' knowledge and the building of teachers' communities of practices as a phase in bridging the gap between the learning of mathematics and subsequent teaching. The study also shows that the implementation of LS in Israel needs appropriate adaptation to Israeli school culture, as would any other approach for the professional development of mathematics teachers borrowed from other cultures. The study outlines the direction for such an adaptation.

Limitations of the study

Although the findings demonstrate that teachers learn through participation in LS, the study does not analyze the sustainability of the revealed changes. Additionally, replicability is limited because of the limited scope of the study's findings.

Recommendations for future research

The following research questions can be raised in follow-up studies:

1. Are the changes revealed in this investigation sustained without further intervention of the researcher?
    a) Do teachers continue team meetings, group lesson observations, collective planning, and reflection?
    b) Do they discuss collaboratively the nature and quality of the mathematical tasks that they devolve to their students?
2. If the study is replicated:
    a) Are the results repeated within different groups of teachers?
    b) How do student achievements change?
    c) How do student attitudes towards mathematics lessons change?
3. Are the categories for analysis of teaching devised in this study effective in the analysis of teachers' professional development in a different framework?