Professional Development of Mathematics Teachers in Planning and Executing a Lesson Integrated with Technology and Self-regulation Using the Japanese Approach

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Abstract

Many countries invest efforts in fulfilling challenges regarding significant and relevant learning in the 21st century, as well as of learning that emphasizes skills such as problem solving, valuable use of technology and self-regulation learning. These skills advance the students' achievements, particularly in the field of mathematics. In order to achieve these goals, programs for the professional development of teachers are implemented. The professional development of teachers poses a dual meaning for teachers, both as learners and as teachers (Kramarski & Kohen, 2016).

Recently, many countries including Israel, have been taking an example from education systems in other countries where the students' mathematical achievements are high. For instance, the teaching of mathematics in Japan which gained an international name. Following the significant achievements of Japanese students in the TIMSS and PISA tests, studies were conducted in the purpose of investigating the factors leading to such success (Lewis, 2002, 2005; Stigler & Hiebert, 1999). In a video study conducted on the TIMSS tests and the Japanese model for professional development, "lesson study", it was found that the Japanese teachers operate in a unique teaching approach. The general approach in Japan for teaching mathematics is **teaching through problem solving**, as opposed to teaching how to solve problems. Teaching through problem solving in the Japanese approach emphasizes the importance in meticulously planning a strict and detailed mathematics lesson with unique characteristics. The execution of the lesson concerns a teaching manner where the students are active participants while practicing problem solving, which leads to deeper mathematical knowledge. According to the Japanese approach, the teacher's role is to create learning opportunities for the students through problem solving. However, teaching in this approach is not an easy task for the teachers in Japan or in other countries attempting to imitate this approach. Fuji and Takahashi (Fujii & Takahashi, 2015) note that the findings regarding the efficiency of the Japanese approach in other countries are inconclusive, a fact which may indicate that the accomplishments of the system in Japan is derived from cultural differences rather than from the uniqueness of the method. In light of this, they note that there is a need to further investigate the conditions required for the professional development of teachers in order to obtain and operate it in school and to advance the students' achievements by using this method.

Integrating technological tools in teaching and cultivating self-regulation processes in learning were set as important standards by the National Council of Teachers of Mathematics (NCTM, 2000). Studies indicate that integrating technological means in teaching mathematics is vital for developing the knowledge and skills required for optimal functioning in the 21st century (a comprehensive report on the status of mathematics studies in the American Education System, 2008). In recent years, integration of technological tools in mathematics lessons, in which they pose an added value, has become a central goal of the supervisors of mathematics in Israel as well. Therefore, there is importance in investigating the Japanese approach which integrates the knowledge of pedagogical and technological content in planning teaching through problem solving.

Currently, only few studies examine the professional development of mathematics teachers who participated in frameworks of teaching in the Japanese approach and its effect on the students' achievements in various countries (For instance, Aravena & Caamaño, 2008). Majority of these studies were case studies and did not examine a large group of mathematics teachers (Robinson & Leikin, 2012). **Thus far, no studies were conducted on the professional development of teachers in the Japanese approach and the advancement of their students' achievements by cultivating Self-regulation learning (SRL) among teachers and integrating technology in the framework of professional training**.

This study has two goals. The first goal is constructing **a program for professional development** of mathematics teachers with the purpose of improving the mathematics lessons by **teaching through problem solving in the Japanese approach in a technological environment by cultivating the self-regulation learning (SRL).** The second goal is examining the efficiency of this program among the teachers both in aspects of planning the lesson and in executing it and its effect on the students' accomplishments.

This study examined **three aspects**: acquiring **knowledge and actual practice** of the teachers and **assessing the knowledge** among the students.

The teachers' **knowledge level** was examined by: 1. **Solving mathematics problems**; 2. **Teaching Pedagogical Content Knowledge (TPCK)**; 3. **Self-regulation learning (SRL)**. **The level of practice was examined in the planning and**

execution of the lesson, while integrating technology and referring to **pedagogical beliefs** which are derived from the planning and the execution of the lesson.

Parallel variables were examined among the students: solving mathematical problems, self-regulation learning and pedagogical beliefs.

In the study participated mathematics elementary teachers, in three study groups constructed in a gradual manner which allows **seclusion of variables**:

Group 1: Problem solving + SRL – this group was exposed to **planning and executing a lesson** by teaching through **problem solving in the Japanese approach**, while integrating **technology** and cultivating the skill of **self-regulation learning**.

Group 2: problem solving – this group was exposed to planning and executing the lesson by teaching through **problem solving in the Japanese approach** while integrating **technology**, **without** placing an emphasis on self-regulation learning.

Group 3: control – this group was exposed to teaching according to the goals of the **new mathematics program**, **without** teaching through problem solving in the Japanese approach and **without** placing an explicit emphasis on self-regulation or on integrating technology.

The current study is a **broad study** conducted in an mixed method approach, both qualitative and quantitative, while using declarative tools (questionnaires and exams), real time assessment (planning and execution), videotaped lessons to examine **the teachers' knowledge** (N = 115) and an **in-depth study** to examine their **practice** in planning and executing a lesson (focus group N = 18), while integrating technology (First research question). Furthermore, the study examined the effect of these aspects on all of the students who participated in the study (N = 406), as well as on **a focus group of students** (N = 75), through a "**thinking aloud**" analysis while solving problems (second research question).

Overall, the classification of the findings on the study groups **was found to correlate with the nature of the explicit support given to the groups**. The prominent findings support the importance of self-regulation learning while integrating technology in the Japanese approach both in the teachers' achievements (knowledge and practice) and in the students' "thinking aloud solutions" (focus group). It was found that **teachers of the problem solving + SRL group** exhibited significant changes

compared to teachers in the two other groups (problem solving and control) in the examined components: **knowledge** of **problem solving in the explanation level**, knowledge of a **solution strategy** and **self-regulation** during problem solving as well as **knowledge** of **Technological Pedagogical Content with a technological integration – TPCK**, in **self-regulation**, in learning and in **performing and executing** a lesson according to the Japanese approach.

The **differences between the problem-solving group and the control group** among the problem-solving group with regard to the practical aspect of executing the lesson, which was more complex in character, was found to be prominent. This finding indicates that the Japanese approach cultivated elements of self-regulation learning in the problem-solving group as well, although, less effectively and not explicitly. The control group exhibited improvements in a number of measures in planning the lesson, including the use of a variety of strategies and the handling of difficulties to which it was exposed during the training. However, among the teachers, this group exhibited a difficulty in executing the lesson.

On the other hand, in **executing the lesson**, it was found that teachers in the **problem solving + SRL group** exhibited significantly greater changes than the teachers in the two other group, in each of the six measures defined in the study according to the theoretical approaches in the basis of the professional development program: **the manner of introducing the problem**, **identification of decision points, handling difficulties, cultivating active learning, integration of technology in the lesson and the pedagogical beliefs** that are derived from it. These findings are in line with the findings in previous studies conducted on **expert teachers** who optimally **organize and present the knowledge of the content** they use, and specifically on teachers who optimally conduct lessons in the Japanese approach (Borko, Jacobs, Kohllner, & Swackhamer, 2015; Hattie, 2012; Hino, 2015; Isoda, Stephens, Ohara, & Miyakawa, 2007). These teachers present the learned materials while connecting it to prior knowledge and other topics learned.

With regard to the achievements of students in the **aloud solution** (focus group), no differences were found between groups in the correctness of solving the mathematical problems. However, **an advantage was found in both groups executing the Japanese approach** (problem solving + SRL and problem solving), compared to

the control group in the measure of **the strategic level of problem solving**. An advantage was also found for the **integrated group** (problem solving + SRL) compared to the two other groups (problem solving and control) in the **level of self-regulation** during an aloud solution.

The advantage of the **integrated group** compared to the two other groups was also expressed by the level of **pedagogical beliefs**, which emphasizes the importance of centering the learning in an active and initiative learner.

This study contributes in a number of aspects:

In the **theoretical aspect**, it offers a model for professional development which integrates between two different theoretical approaches for teaching: the **Japanese** approach through problem solving, the **integrative** approach of learning while integrating technology (TPCK) as well as the **self-regulation** learning approach (SRL). An examination of the three approaches in **one comprehensive** study and the construction of matching intervention programs which allow **isolating variables**, is a **novelty in research** with an **added value** of understanding the optimal conditions for teaching in the Japanese approach.

In the **methodological aspect**, the study presented many diversified findings analyzed via **integrative study methods**, qualitative and quantitative, and its **conclusions** can contribute to **decision makers and future researchers** in the research field. The study offers **assessment methods and reliable guides** for examining **lesson planning** in the Japanese approach and **assessment of the actual performance**, as part of the professional development of mathematics teachers, on the basis of concepts and theories validated in the study.

In the practical aspect, in addition to the theoretical aspect of professional development, the study proposes **ways of implementing it** in a technological environment with the help of self-regulation learning via **self-questions** which were proven effective in previous studies (such as Mevarech & Kramarski, 2014), as well as in the current study.