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The Contribution of In-Service Training Programs to the Professional Development of Mathematics Teachers

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Abstract. This paper presents a way of training elementary school mathematics teachers. The viewpoint taken is that the teaching profession is a continuous learning process for those who practice it. The first part will present a model of mathematics teachers in-service training program conceived by the authors and later tested and researched. The second part will present examples from the curriculum of the in-service training program. It will touch upon the manner by which mathematics teachers are instructed and encouraged to carry out projects in their schools.

Keywords: Mathematics teacher; professional development; mathematics projects

Model of mathematics teachers in-service training program

In recent years, mathematics teachers educators have emphasized the importance of implementing a reform in mathematics teaching. In Israel, there are more than 16,000 mathematics teachers, about 9,400 of them teaching mathematics in elemetary schools. But only 20% of the latter have specialized in teaching mathematics. Although the majority of elementary school teachers lack formal mathematics education and their knowledge is limited, in many cases they do teach mathematics. Hence, in order to change the situation, it is essential to build programs designed to develop and support the growth of these teachers' professional knowledge.

Teaching is a very complex and demanding profession and at the same time extremely challenging. As Shulman (1986) said: "*The person who presumes to teach a subject matter to children must demonstrate knowledge of that subject matter as a prerequisite of teaching*". Nevertheless, this is insufficient. Teachers need to possess a wide range

of 6 skills and various types of knowledge and abilities (Danielson, 2001; Shulman, 1987) as follows: pedagogical knowledge concerning available teaching materials and methods; knowledge and abilities for adapting teaching approaches to specific subjects and the reasons thereof; knowledge and abilities for designing lessons, asking questions and presenting problems; knowledge and abilities about students: difficulties, mistakes and misconceptions they have, and the ways students construct their knowledge; knowledge and abilities of being reflective: ways of analysing what the teacher did, how and why the teacher did it.; knowledgw and abilities of communicating and interacting with students.

Ball (2011) dealt with the question of "Knowing mathematics well enough to teach it". She raised three questions: How much mathematics do teachers need to know? What mathematics do teachers need to know and why? What mathematical knowledge and skills are involved in teaching?

Guberman and Gorev (2012) identified teachers' attitudes towards the knowledge which they need in order to fulfill their role in the best way. They found three important components: the component of mathematics knowledge, the component of mathematical pedagogical knowledge and the component of knowledge about the curricula.

Thus, they attempted to define what should be emphasized in the training of elementary school mathematics teachers. Among others, this can be done by participating in the preparation of workshops devoted to professional development and taking part in life-long learning.

We can summarize what has been said above into a model of "**The personal practical knowledge of the teacher"** which comprises a set of six components. **Knowledge of the subject matter** - understanding the structure of the field of knowledge, ideas, principles and key concepts in the disciplines as well as educational content and knowledge organization. **Knowledge of the learner** - understanding learning and development among students, level of difficulty and adjusting the material to the students' differentiation. **Background knowledge of the school environment** - understanding contexts, norms and relationships within the school, community, parents and authorities. **Curricular knowledge** - knowledge of existing curricula and learning materials, alternative materials, exploring connections between content areas, different subjects and different levels for the same age group. **Didactic knowledge** - knowledge of teaching practices, recognizing and using different teaching strategies, varied classroom management and organization, different alternatives in teaching. **Self-knowledge** - personal goals, values, awareness, beliefs and opinions that affect curriculum planning and teaching.

The model

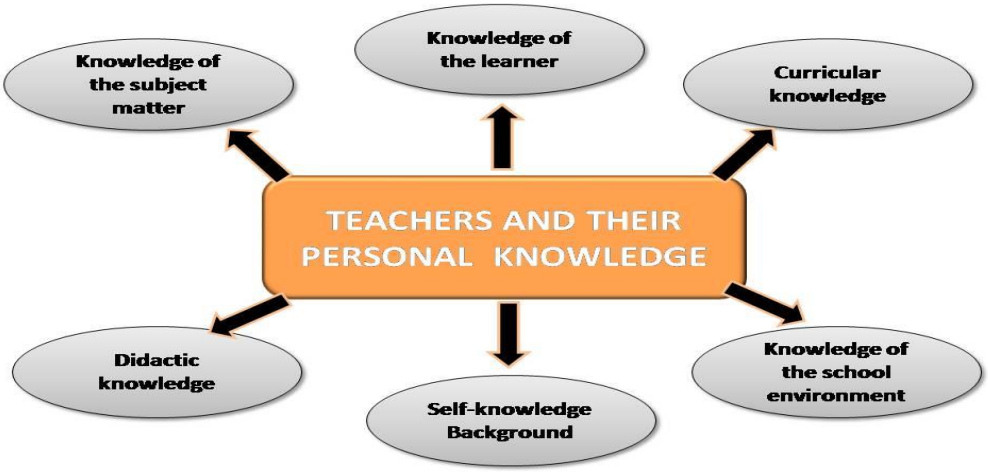

Figure 1. Teachers and their personal knowledge

In order to strengthen teachers' mathematical and pedagogical knowledge educational authorities in Israel decided at the beginning of the 21st century to develop professional programs that respond to teachers' major needs. The aim of the new in-service training program was to promote academic achievements in elementary school mathematics. The program was called "**Specialization in mathematics**". It was compulsory for all "nonprofessional" teachers, namely teachers who did not have formal mathematics education.

At the same time, the elementary school mathematics curriculum prevalent in the education system for over 20 years was replaced by a new program.
The in-service training program was designed to last 2 years, 150 hours a year, totaling 300 hours. The program aimed to strengthen teachers' mathematics knowledge as well as their acquaintance with the new elementary school curriculum. The didactic aspects were designed to instruct teachers with several models of teaching and learning, adjusting them to different age levels. Moreover, the participant teachers were introduced to students' errors and common misconceptions in the context of learning mathematical concepts, using them as a means of correcting or preventing them. In this context, another goal of the program was to empower teachers who could develop learning environments tailored to a variety of student types. The program also emphasized providing knowledge for implementing varied ways for assessing students' performance.

Teamwork skills were also some of the goals of the in-service training program. According of the program, teachers should learn to cooperate with their team

colleagues, design together the work plan, set goals, as well as systemically test and assess outcomes of learning processes.
The in-service training program was planned to include 10 modules and two external tests: two base modules (geometry and fractions), five advanced modules (geometry, fractions, integers, ratio, percentage and exploratory data analysis) and two modules of empowerment of school staffs and teamwork skills.

First year

Semester I: Basic geometry, basic fractions.

Between the semesters: empowerment of school staffs and teamwork skills by creating an intervention project in geometry (like geometry around us).

Semester II: integers, advanced geometry.

At the end of the first year, the teachers had to pass an exam written by the inspector of mathematics.

Second year

Semester I: advanced fractions, exploratory data analysis.

Between the semesters: empowerment of school staffs and teamwork skills by creating an intervention project in mathematics and language (e.g. mathematics in stories and fairy tales).

Semester II: ratio and percentage, dealing with learning disabilities and gifted children.

At the end of the second year the teachers had to pass a certification test which included all the topics of the 10 modules.

This in-service training program continued for 9 years, till 2010. The results brought only limited success. The National Authority for Measurement and Assessment in Education published a report in 2011. The report illustrated that the rate of teachers who had successfully completed the professionalization program during the years 2004-2010 (as measured by the final exams which included contents from the learning materials the teachers were supposed to teach), ranged between 63% and 85%. Moreover, only about half of the teachers who taught mathematics in elementary school participated in the program and many schools sent only individual representatives and not teams of teachers.
Shriki and Patkin (2012) found that most of the teachers who attended the in-service training program in mathematics stated that the program didn't have real impact on their teaching. Teachers were mainly concerned about their difficulties in dealing with mathematically heterogeneous classes and their insufficient knowledge about

appropriate learning materials and the ways to adapt them to students' various abilities. The teachers also pointed out that they needed to be able to deal with affective aspects of learning mathematics - how to motivate students to learn mathematics, how to reduce fears of mathematics and more. Despite most teachers' insufficient mathematical background, they did not perceive this issue as central to their needs.

The 'New Horizon' educational reform

Four years ago, within the framework of the educational reform 'New Horizon', a setup of teachers' professional development was conceived in Israel (Ministry of Education, 2013).

In mathematics, three new programs were developed: Two pathways of a 3-year long in-service training courses were planned for multiple subject teachers who had not specialized in mathematics and yet teach it at school. The total number of hours in each pathway was 90 hours. The pathways were built according to age groups: a pathway for teachers of 1st -2nd grades and a pathway for teachers of 3rd-6th grades. The objectives of the in-service training program were: building mathematics knowledge; comprehension of and distinction between curricula and learning materials; and development of thinking principles of mathematics. Teachers were required to attend every year two courses, each 30 hours long. One course dealt with the Subject Matter Knowledge (SMK) (e.g. mathematics) and the other was designed according to the needs of the school or the district (e.g. IT, 'caution on the road' rules and so on). Head teachers recommended and authorized the in-service training program as well as chose the teachers who were to attend these courses. It is important to mention that teachers who wish to train in mathematics are allowed to learn without any tests.

Patkin & Mishal (2014) conducted a study which aimed to explore the contribution of mathematics in-service training courses to elementary school teachers (1st – 6th grades). The participants were 449 teachers who were required to respond to background questions. Moreover, they were asked to indicate their expectations from the in-service training course and at its end point out to what extent they benefitted from that course. The research findings illustrated that teachers teaching mathematics at elementary school and who attended the course were generally women. They were in their 40s, holding a B.Ed. degree and a teaching certificate not in mathematics, with an average of 13-year seniority. The participating teachers indicated their wish to enrich their didactic knowledge in order to acquire varied tools for teaching mathematics to the entire pupil population, gifted pupils and pupils with learning difficulties. Nevertheless, their demand to expand their mathematics knowledge was very limited. Based on the fact that most teachers have no mathematics education, this is a surprising finding as, in order to be a good teacher, one must be versed not only in the Pedagogical Content Knowledge but also in the Subject Matter Knowledge.

The third new program was "Teachers initiating and implementing educational programs". The teachers who attended this program had to be experienced and well-educated and should have attended in the past various in-service training programs of mathematics teaching. The program advocated taking into consideration the features of teachers' professional background, including the knowledge, beliefs, needs and expectations which they have brought with them to the in-service training course. It was designed to develop elementary and junior high school mathematics teachers' ability to generate changes in their teaching methods and implement them in class and at school. The program consisted of a total of 150 hours spread over two years. The first year included 45 hours of theoretical studies as well as 30 hours of support and tutoring in the implementation of an applied project (developing initiatives in the field of mathematics teaching). The program comprised 11 encounters of four hours each. Three of them were devoted to the generic part of the program. The other encounters engaged in the content area of the program. At the end of the first year of the program, the attending teachers were required to submit a final assignment. Similarly, the second year of the program included encounters devoted to the inculcation of varied tools for documenting initiatives and teaching/learning processes. In parallel, the encounters focused on theoretical and applied aspects stemming from the development of mathematics teaching units and their implementation as well as tutoring of the applied project.

A study conducted by Levy-Keren (2014) aimed to assess the 2-year in-service training program. The research design was in the 'pre-post' format without a control group. The research population consisted of 19 teachers and the research tools were close-ended questionnaires and a set of open-ended questions. The approach used for analyzing the data was both quantitative and qualitative.

The research findings of this study illustrated that at the end of the first year of the in-service training program the participants demonstrated a slight and insignificant improvement in perceiving their capabilities of understanding mathematics and teaching it. Nevertheless, there was a significant decrease in their level of expectations at the beginning of the in-service training program regarding the contribution of the program related to the inculcation of mathematical knowledge and pedagogical content knowledge. In addition, the teachers were highly satisfied with the whole program. It was evident that the teachers greatly benefited from the teamwork they had experienced for the purpose of planning and implementing the initiative; application of skills for writing the initiative proposal as well as the knowledge they acquired in mathematics and the teaching thereof. Future expectations of most teachers were focused on implementing the initiative and its operation at school during the second year of training. These findings were interpreted through a model for developing teachers' concern about and interest in the change. At the end of the second year, at the end of the in-service training program, the attending teachers responded to a questionnaire which checked the perception of the change in their pedagogical skills following the initiative implementation. Moreover, their attitudes towards the extent to which several elements associated with the processes

functioned. The objective was to identify the aspects which preoccupied and concerned the teachers during the change process which they were undergoing.

The findings were analyzed according to the Concerns Based Adoption Model (CBAM) conceived by Hall & Hord (2011).

Table 1 presents the various elements which facilitated or inhibited the process of implementing the initiative as a process of change in the participants' way of teaching. This was done by means and standard deviation obtained for each element. The answer options ranged between 1 (the element did not help at all) and 6 (the element which helped the most).

Table 1: The facilitating and inhibiting elements which function during the initiative process (means and standard deviation)

The functioning element	N=19	Mean	S.D.
Collaboration between subject colleagues at school	15	5.20	1.01
Lack of budget at school	11	2.91	1.97
Counselling you received during the in-service training course by the lecturer team	15	5.40	1.06
The time you had to dedicate to implementing the initiative	15	5.27	1.10
Supportive school climate	15	5.13	0.74
Ambiguity regarding the nature of the proposed initiative	5	2.40	1.14
The efforts you have to exert for implementing the initiative	15	4.47	1.36

The findings show that elements which were the most facilitating for implementing the initiative are the tutoring the teachers received within the framework of the in-service training program (5.40), the collaboration between colleagues (5.20) and the supportive school climate (5.13). The other two elements – the managerial-organizational element of the lack of budget at school (2.91) and the ambiguity regarding the success of the change (2.40) were perceived as non-facilitating. The summary of the findings analysis illustrated the end of the first year of the in-service training course a slight and insignificant improvement in the way all the teachers perceived their abilities to teach mathematics (Pedagogical Content Knowledge). Conversely, at the end of the second year, after completion of the project, there was clear evidence of improvement in the teachers' pedagogical knowledge following the implementation of the educational initiative at school (Levy-Keren, 2014).

The second part of this paper presents examples from the curriculum of the in-service training programs. This approach encourages schools to introduce projects which are suitable to classes with a large number of students and heterogeneous classes.

Project no 1:

A mathematical journey in the Footsteps of Jules Verne

"Adding creativity to daily teaching practices will ensure that students are given opportunities to develop all of their potential…." (Burke Adams 2007).

As part of mathematics education, the project combines the stories of Jules Verne and mathematical studies, in order to develop skills of connectivity between mathematics and other disciplines. The fascinating journey to the beauty of mathematics is performed through the book of Jules Verne, *Around the World in Eighty Days*.

We based ourselves on the standards of the NCTM (NCTM, 2000) which emphasize this aspect, asserting that this type of relation between mathematics and other areas shows the applicability of mathematics as well as develops comprehension. In the preparation of the learning environment, we grounded ourselves in the arguments that the learning environment was a system of interrelated components that attributes a meaning to one another.

The characteristics of the learning environment in the spirit of Jules Verne's stories were based on four following principles. The first principle is that an environment embodies flexibility of time dedicated to a given learning activity, in the place where the activity occurs, in the modes of possible learning (methods and learning ways), and in the learned contents. The second principle is that teachers' role is to provide opportunities for learning with the world, given learners' curiosity and interest. The teacher helps, catalyzes, directs, and adjusts the learning activity by providing stimuli, offering help, and creating appropriate learning opportunities. The third principles is that the learning environment enables learning situations that rely on the learner's curiosity which evokes inner motivation. The fourth is that the learning environment offers students stimulation and discussions on mathematical topics. It encourages a thinking culture and complex tasks of collecting relevant information.

In the method of activity using Jules Verne's story *Around the World in Eighty Days*, learners wander around a map of the world. Thus they are exposed to the world of numbers, calculations, the history of mathematics, interesting discoveries in mathematics and the tremendous innovation and creativity in the stories of Jules Verne.

For example, while visiting Egypt we can teach Ancient Egyptian Numeration system (one of the "stations" in the book *"Around the World in Eighty Days*) .

How can we write the following numbers using the ancient Egyptian symbols? 431; 1,374 ; 62,589? Did we all use the same symbols? We should check this! If we write the same symbol 3 times in a row (e.g. 3 "birds") what could we say about the numbers we get? When writing the same digit 3 times in a row with our symbols (555 or 888) what can we say about the numbers we get?

Project no 2:

The Mathematical Field Trip

Most studies of mathematics education deal with the difficulties encountered by students in learning mathematics. One of the main reasons for these difficulties is the gap between the level of teaching and students' capabilities and understanding of mathematical concepts (Patkin & Levenberg, 2012). Consequently, it is recommended integrating multi-disciplinary activities into the mathematical teaching using examples which activate the imagination while acquiring mathematical knowledge. In this manner, students will have a more substantial and better understanding of mathematical concepts.

In the Standards for School Mathematics published over the years by the National Council of Mathematical Teachers (NCTM, 2000) many suggestions have been made to improve mathematical teaching in school and to adjust it to the technological needs of the 21st century. These suggestions are based on the assumption that the field of mathematics includes content matter from a wide variety of subjects that are essential for students learning in a technological society. The Standards recommend using auxiliary materials in mathematical teaching which aid the students by emphasizing inculcation and development of cognitive skills as well as understanding mathematical concepts. The ultimate goal is to develop mathematical literacy: reading, speaking and writing mathematics. These recommendations provide the foundation for the mathematical field trip (Shaham & Levenberg , 2013).

The trip in the school's neighborhood covered a number of sites and combined historical and geographical perspectives along with mathematics. Several goals were accomplished during the mathematical tour. These were: acquiring knowledge through experience and inquisitiveness; changing the learning environment into an open and inviting dynamic environment outside the school classroom; developing the student's ability to cope with relevant problems, applying tools from diverse fields; demonstrating the relation between mathematics and disciplines such as: history, geography, physics and others; and reducing the anxiety of learning mathematics.

The preparations of the mathematical field trip required Providing a source for mathematical activity, choosing photographed sites, researching historical and geographical backgrounds of the chosen sites, adapting the level the activities to the level of mathematics taught at the school, preparing a wide variety of mathematical activities and assessing all the activities at the end the field trip.

The mathematical field trip was unique because it integrated mathematical principles taught in elementary school and applied them to the immediate environment. The subjects involved in the trip included measurements, the world of whole and rational numbers, geometric shapes, symmetry, percentage, fractions and so on.

The field trip suggested a wide variety of mathematical activities and exposure to subject matter outside the classroom. It enabled interesting and non-conventional mathematical activities to pupils at elementary school level. The children learnt

mathematics through experience and inquisitiveness and developed the ability to cope with relevant problems. In addition, they learnt more about the relations between mathematics and other fields of learning such as: biology, history, geography, physics, economics and other disciplines. Moreover, the mathematical field trip developed mathematical activity in a different and challenging learning atmosphere.

Below are some vignettes of students feedback associated with the mathematical field trip:

"We had a chance to see math outside the classroom"; "We learned math together with biology, history, geography, economics, we didn't have it before"; "The activities were interesting and challenging"; "We would like to have more activities like this".

Discussion and recommendations

Based on the teachers' satisfaction with the three new developed programs, it is recommended implementing them also in the next years. This should be done by paying attention to teachers' professional background characteristics, including their knowledge, beliefs, needs and expectations they bring with them to the in-service training courses.

Nevertheless, one should bear in mind that different studies illustrate that the very attendance of teachers in programs designed to support their professional development is insufficient and as such cannot guarantee the anticipated change in their professional practice (Guskey, 2000). Consequently, it is essential that teachers continuously explore the initiatives they have developed and the impact thereof on their pupils' learning and learning outcomes.

Moreover it is recommended setting up in future a professional development community (CDP). This concerns a group of professional that critically and jointly examine their knowledge and practices, discussing them with the purpose of improving from a professional aspect. Such a group could facilitate teachers in coping with the elements which they believe inhibit the internalization of the initiative, e.g. feelings of apprehension, lack of confidence and available time resources. They should be allowed to implement the initiative also in the next years in the scopes they wish. Within the professional development community the teachers would be able to share with others the processes of data collection and analysis, examine evidence regarding the relation between the initiative implementation and their pupils' learning outcomes, analyze teaching and learning processes, draw conclusions and generate changes designed to improve their teaching and the learning of their class pupils (Levy-Keren, 2014; Louis, Marks & Kruse, 1996). This activity, according to the various studies, enhances teachers' sense of self-efficacy and their personal commitment to teaching and improving the pupils' attainments (Levy-Keren, 2014; Louis, Marks & Kruse, 1996).

Implementation of these recommendations might lead to teachers' continuous learning throughout their career, promote them and turn them into experts in their

field. Thus they will acquire pedagogical knowledge and updated education, improve their practice and upgrade the pupils' attainments.

To sum up: Every country copes with varied problems associated with teacher training and professional development throughout the years, as a way of life. In light of the numerous and rapid changes which transpire in the 21st century, mathematics teacher in-service training programs, like other professions such as engineering and medicine, have become more difficult and complicated. Consequently, international collaboration and mutual feedback are the most important and beneficial factors in promoting this issue.

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