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By
Smadar Levy

מאת
סמדר לוי

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Professional Development of Leading Physics Teachers
in a Professional Learning Community

Advisors:

Prof. Bat-Sheva Eylon
Dr. Esther Bagno

מנחות:

פרופ' בת שבע אלון
ד"ר אסתר בגנו

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אדר תשע"ז

Abstract

This study examines a professional development program for leading physics teachers in the framework of Professional Learning Communities (PLC). The main purpose of the program is professional development of the leading teachers, both as teachers and as leaders of physics teachers' regional PLCs. This is in order to address the challenges of physics teaching, such as physics being considered a difficult subject in schools, and the fact that in many schools physics teachers have no colleagues for consultation and support. The main goals of the program are to enable physics teachers in collaborative examination of their teaching and their students' learning and to promote Student Centered teaching methods.

The leading teachers' professional development is enacted in a Professional Learning Community (PLC), led by a team from the Weizmann Institute of Science, in a "Fan Model". The program is based on the leading teachers' active experiences as learners, as classroom teachers and as leaders of physics teachers in regional PLCs all over Israel. The approach is evidence-based and encourages collaborative reflection regarding learning, teaching and the leading of PLCs. The main issues in the program are: the use of Student Centered teaching methods, enriching physics instruction in order to attract more students to study physics, deepening both content knowledge and pedagogical content knowledge, acquiring leadership skills and more.

The physics teachers' PLC program began in 2012 with 6 leading teachers and 3 regional PLCs. In the current year, 2017, there are 25 leading teachers in the program and 10 physics teachers' PLCs all over Israel (working with approximately 200 high school physics teachers).

The leading teachers' PLC meetings take place at the Weizmann Institute of Science. Each PLC activity, both the leading teachers' and regional PLCs, consists of face-to-face meetings lasting four hours each, once every two weeks during the school year, totaling 60 hours per year.

The literature reports the importance of leading teachers in developing effective PLCs, the need for professional development of leading teachers and also that there is a lack of research dealing with programs for professional development of leading teachers. This is what this research is aimed to do.

The population of this research involves experienced physics teachers who are members of the leading teachers' PLC. New leading teachers join the leading teachers' PLC every year, so that senior and new members learn together.

Research Goals:

1. To study the processes of leading teachers' knowledge construction and the relationships between changes in their knowledge, perceptions and practice as classroom teachers and as PLC leaders.
2. To identify the central mechanisms in the program which operate to promote changes in knowledge, perception and practices of leading teachers, both as classroom teachers and as PLC leaders.
3. To study the implementation of new teaching strategies offered in the program in both leading teachers' classrooms and those of regional PLC teachers.

Theoretical frameworks

In this study, in order to characterize the knowledge leading physics teachers must have, especially in the context of PLCs, we developed the theoretical framework PKTL - Physics Knowledge for Teaching and Leading, based on MKT, intended for teachers of mathematics (Ball, Thames & Phelps, 2008). In order to analyze the process of knowledge construction by the leading teachers, we integrated PKTL and the framework of "Knowledge Integration", developed by Linn & Eylon, 2006; 2011.

In order to describe and analyze the professional development of the leading teachers, we developed an additional theoretical framework, based on the Interconnected Model of Clarke & Hollingsworth (2002), which we expanded and adjusted to the professional world of leading physics teachers.

Our data analysis is primarily based on qualitative methods, but we also used descriptive statistics.

Changes in knowledge, perceptions and practice of leading teachers

The leading teachers went through a complex, ongoing process of professional development, which led to changes in their knowledge, perceptions, and practices - both as teachers and as PLC leaders - over a long period of time.

The findings indicate advancement of their knowledge in most aspects required of leading teachers in physics, such as: physics, physics teaching, students' learning of physics, pedagogy, and also teachers' learning processes and instruction of teachers. The processes of change we found in their knowledge, perceptions and teaching practices match professional growth of teachers according to Clarke & Hollingsworth (2002). The findings in this current study add an important aspect - the professional development of leading teachers, who, in addition to the changes they themselves underwent, also succeeded in promoting changes in knowledge, perceptions and teaching practices of the teachers in the PLCs.

The developmental process of the leading teachers as PLC leaders was especially complex. Differences were found between new and senior leading teachers in terms of support needed in order to plan a good session for the PLC. At first, the newer leading teachers primarily focused on instruction practices regarding their PLCs and less on learning processes, feelings and difficulties the teachers in the PLC encountered. As time went by, however, the leading teachers learned to plan the PLC meetings more cautiously, in accordance with the preferences and needs of the teachers, while promoting learning processes and the program's goals.

The main mechanisms in the program which promoted changes in knowledge, perception and teaching practices of the leading teachers

The similar features we found in the change processes in knowledge, perceptions and practice of the leading teachers, enabled us to identify the main mechanisms in the program which promoted these changes.

The professional development model of leading teachers significantly enhanced professional development of the leading teachers. This model is based on active experience of the leading teachers in all arenas of their activity: as learners at leading teachers' meetings, as classroom teachers and as regional PLCs leaders. They went through processes of experience, collection and analysis of evidence and reflection in each arena: the leading teachers' PLC, the leading teachers' classrooms and the regional PLCs.

The findings indicate an additional important arena: the classrooms of regional PLC teachers. Although leading teachers were not directly involved in that arena, it had an influence on their professional development, through collaborative reflection about the teachers' experiences in class. Our findings indicate that leading teachers' learning was enhanced, due to the relationships between their own learning and their practice as classroom teachers and as PLC leaders. The alternating sessions of regional PLCs and the leading teachers' PLC every other week contributed to this.

Furthermore, the findings show that the "Fan Model", implemented in our program, works in two directions: Learning processes did not occur only from "top down", from the Weizmann Institute's team to leading teachers and all the way to regional PLCs' teachers and their students, but also "bottom up": Evidence and insights from leading teachers' classrooms, from regional PLCs and even from teachers' classrooms affected the learning processes of the leading teachers and the team at the Weizmann Institute of Science. The findings also show mutual influences of leading teachers on each other.

The processes of enactment and reflection were identified as mechanisms which promoted changes in knowledge, in perceptions and in practice of leading teachers, as in the Clark & Hollingsworth model (2002), on which we based ours.

Moreover, our findings indicate that construction of enactment and reflection in the program in a certain order and at appropriate timing, in all the arenas of leading teachers' activity, increased leading teachers' motivation to go through multiple sessions of enactment and reflection and contributed to their professional development.

Cognitive apprenticeship (Collins, Brown and Newman, 1987) is used in the program as a central mechanism for training the leading teachers to be leaders of PLCs. Findings show that cognitive apprenticeship enabled the leading teachers to gradually acquire the necessary skills, along with their practice as leaders of PLCs. The model presented in the leading teachers' meetings and the scaffolding in and between the meetings greatly influenced their practice as PLC leaders. Email was found as the main communication tool used between meetings and as a means with which to help and support leading teachers.

The academic backing of the Weizmann Institute of Science is of great importance according to our findings, and has enabled the leading teachers to have a constant access to expertise in physics and in physics education. The program is based on current approaches in physics teaching and uses research-based instructional methods. Special teaching materials were developed for the physics teachers' PLCs.

The teaching materials that were used in the program acted as mechanisms that organized, directed and promoted the learning processes of the leading teachers. Findings indicate the importance of adjusting teaching materials for immediate use in classrooms: adjustment to the curriculum, adjustment to timing during the school year and a variety of examples in different subjects. This way the leading teachers had a chance to try each new activity in class right after they experienced it as learners in the leading teachers' PLC and before using it in the regional PLCs.

The facilitating approach in leading teachers' PLC, which integrates planning ahead together with adjusting to the leading teachers' preferences and needs, contributed significantly to the professional development of the leading teachers. Also important was the fact that the leaders of the leading teachers' PLC are themselves experienced physics teachers and also leaders of regional PLCs.

The leading teachers' community, as a professional learning community, turned out to be an enriching, supportive and protective learning environment, in which leading teachers shared learning processes with peers who were having similar experiences and which actually enabled a conceptual change regarding new teaching methods and the roles of classroom teachers and leading teachers.

Leading teachers identified with the physics teachers PLC program and felt that they were part of an important project.

Implementation of the program's new teaching methods in the classroom

According to our findings, all of the leading teachers and most of the regional PLC teachers regularly use the new teaching strategies offered in the program in their classrooms, often for a year and even two years after they learn them. Approximately 70% of the students of regional PLCs' teachers reported that these methods were used in their classroom at least twice a year.

Regarding the extent of implementation of new teaching strategies, differences were found between leading teachers and teachers of regional PLCs. In cases where application of new teaching strategies was relatively easy in terms of the conceptual change the teacher had to go through and the challenges involved in the activity, the gap between leading teachers and teachers in PLCs was relatively small. The more challenging implementation of an activity was, the larger the gap was between leading teachers and regional PLC teachers.

Theoretical and methodological contribution of this study

This study addresses the need reported in the literature for research about training and professional development of leading teachers, particularly in the context of teacher PLCs. In addition, we developed the theoretical frameworks, PKTL for characterizing the leading teachers' knowledge, and the Interconnected Model for describing the professional development of leading teachers. Both frameworks were also adjusted and used as methodological tools.

Practical implications of this study

The findings of this study show that new physics teaching approaches have been implemented in both leading teachers' classrooms and the classrooms of regional PLC teachers. They also show that physics instruction has become more enriched and Student Centered.

This study also has implications regarding current programs dealing with professional development of both teachers and leading teachers in the educational system as indicated in the national report on leading teachers (Michaeli & Somer, 2014). In practice, in the last several years, the model of leading teachers described in this thesis has had major impact on similar disciplinary PLCs programs in chemistry, mathematics, junior high sciences and more. The team of the project has been sharing the insights gained through this study and through our experience with leading teachers in PLCs.