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RESEARCH ARTICLE

Using the Action Research rationale to enhance the creation of teachers' Professional Learning Communities (PLCs)

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Creating teachers' professional learning communities (PLCs) is an effective bottom-up way of bringing innovation into the science curriculum and professional development. The models of PLCs are based on principles of learning that emphasize the co-construction of knowledge by learners, who in this case are the teachers themselves. Teachers in a PLC meet regularly to explore their practices and the learning outcomes of their students, conduct action research activities - analyze their teaching and their students' learning processes, draw conclusions, and make changes in order to improve their teaching and the learning of their students. It was found that participation in an action research workshop in the framework of PLC, influences teaching practice, so teachers become more student-centered. Moreover, the teaching culture improves as the community increases the degree of cooperation among teachers, as well as the creation of transformative pedagogy, focusing on the processes of learning rather than the accumulation of knowledge. This enables students to be innovative, creative, and critical. In addition, trust is developed among the participants, which enables them to discuss and analyze their students' cognitive and affective problems, misconceptions, and learning outcomes, towards adapting a transformative pedagogy to teaching.

Keywords: Professional development of chemistry teachers; professional learning communities; action research; reflective teachers.

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Introduction

Action research is an inquiry into teachers' work and their students' learning in the classroom (Feldman & Minstrel, 2000). Feldman (1996) claims, the primary goal of action research is not to generate new knowledge, whether more local or universal but rather, to improve and change classroom practices. Nevertheless, this point may be viewed differently depending on the action research mode chosen and depending on the objectives negotiated within the group of practitioners and researchers (Eilks & Ralle, 2002). In the end, the development of individual practices and generation of results of general interest can be understood as two sides of the same coin, with both having equal importance.

The process of action research can be described as a cycle of planning, implementation, observation, and reflection. Implementing changes and improving classroom practices is an iterative process (Zuber-Skerritt, 1996). Each cycle of action research is repeated and all cycles form a spiral. These cycles allow teachers and researchers to evaluate classroom practices for ongoing improvement (Towns, Kreke, & Fields, 2000). The way action research is done (cyclical) is one of the main differences between action research and more conventional research (Wadsworth, 1998).

The main objective of the action research activities described in this paper, was to enhance the chances of creating a professional community of chemistry teachers (Mamlok-Naaman & Eilks, 2012). The participants in the Tira community had many opportunities to enhance their social skills through collaboration and cooperation with their peers. They shared ideas, consulted with each other, and maintained good social and professional relations with the others. The PLC meetings enabled them to consult with each other and exchange information and ideas as often as they wished. The cooperation between the teachers in the group was fruitful and helped promote their teaching strategies, as well as their professional development (Laudonia, Mamlok-Naaman, Abels & Eilks., 2017).

Professional learning communities of teachers

Creating teachers' professional learning communities is an effective bottom-up way of bringing innovation into the science curriculum and professional development. The models of professional learning communities are based on principles of learning that emphasize the co-construction of knowledge by learners, who in this case are the teachers themselves. Teachers in a professional learning community meet regularly to explore their practices and the learning outcomes of their students, analyze their teaching and their students' learning processes, draw conclusions, and make changes in order to improve their teaching and the learning of their students (Tschannen-Moran, 2014). The concept of PLC arose in the field of education in the context of workplace-based studies conducted in the 1980s that addressed teachers whose professional relations were characterized by continuous striving for improvement, focused on student learning, and who collaborated and explored their work. Such relationships differ from the norms used in the teaching of a more individualistic culture, which typically characterizes schools as a place of work (Lortie & Clement, 1975).

In 1982, Little conducted an anthropological study of six primary and secondary schools in four counties in the western US. He found that schools with norms of collaboration, collegiality, and research could respond better to the pressures of external changes and education initiatives (Little, 1982; 2012). This finding was reinforced by Rosenholtz (1989), who combined surveys and interviews with 78 primary schools. She distinguished rich and poor schools with respect to learning. The learning-rich schools were more likely to establish norms of cooperation and continuous improvement.

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Newmann (1996) argued that a professional community of teachers offers a supportive environment in which teacher learning can occur. For example, the Center for Organizing and Building in Schools at the University of Wisconsin conducted systematic research on 24 primaries, junior high, and high schools in which structural and organizational changes were carried out, with an emphasis on the quality of instruction in mathematics and social sciences. It was found that aspects of a school's professional community that include common norms and values, a focus on student learning, reflective dialogue, transformation of teachers' practice in public classes, and a focus on collaboration, are linked to robust teaching and support for teacher learning.

In a series of articles based on analysis of the NELS:88 databases, Lee, Smith and Corninger (1997) argued that more organized schools produce higher levels of teacher satisfaction, positive student behavior, problem-solving pedagogy, and understanding and learning in mathematics and science. "Our results indicate that when there is a professional community of teachers - when teachers are taking responsibility for the success of all their students - more than learning is occurring" (Lee et al., 1997, p. 142).

Shulman (1997), in his lecture at the Mandel Institute in Israel, spoke enthusiastically about the idea of both teacher communities and student communities. Shulman argued that since a single teacher can never possess perfect knowledge of pedagogical content, we must continue to create conditions in which a teacher can collaborate with other teachers and be part of a community of teachers facing difficult teaching challenges. In other fields, no one expects a single professional working alone to solve an important problem, because complex, real-world problems require distributed expertise - the sharing of highly specialized professionals in dealing with common challenges. Thus, the teachers experienced action research activities, since action research is regarded either as a practitioner-oriented inquiry into teachers' work and their students' learning in the classroom (Feldman & Minstrel, 2000) or as the development of new teaching strategies oriented on teachers' and students' deficits or personal interests (Eilks & Ralle, 2002).

Bryk, Gomez and Grunow (2010) identified professional communities, along with a work culture oriented toward improvement and access to professional development, with elements of professional capacity associated with improvements measured in primary school achievement in Chicago over a period of 6 years in the 1990s. A recent study by Kraft and Papay (2014) reinforced this important insight. These researchers used a measure for the professional environment that was composed of the responses of teachers to a survey in North Carolina combined with a national test in mathematics and elementary school reading. They found that teachers who work in a supportive environment, compared to those who work in a less supportive one, have increased effectiveness over time.

PLC workshops for chemistry teachers in Israel

PLC workshops for chemistry teachers were initiated in Israel 2 years ago. These workshops were supported by the Ministry of Education and sponsored by the Trump Foundation, the Weizmann Institute of Science, and the National Center of Chemistry Teachers at the Weizmann Institute. The workshop operates on a cascade model: a leading team of researchers guides a group of teachers who will lead communities of teachers in regional professional learning communities close to home (see Figure 1).

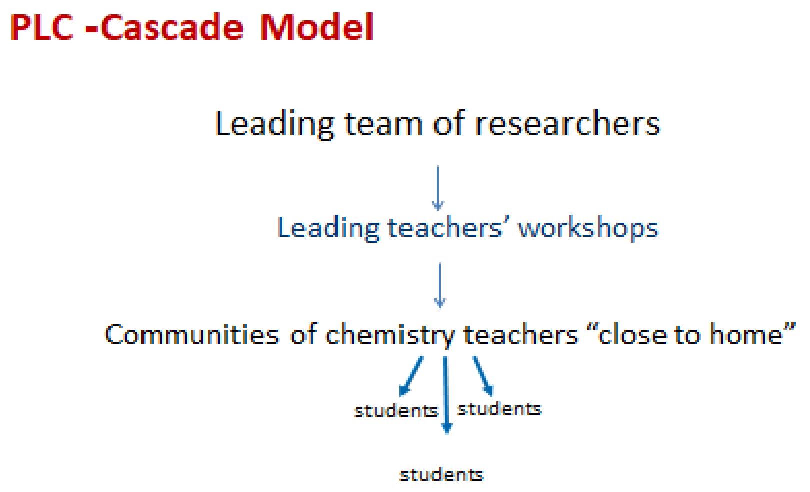

Figure 1. The PLC cascade model (Mamlok-Naaman, Eilks, Bodner & Hofstein, 2018)

A leading team of researchers guides a group of teachers who will become leading teachers, and coordinate regional communities of teachers, professional learning communities close to home. So far, there are eight regional communities of chemistry teachers in Israel, consisting of Jewish and Arab high school teachers. Each professional learning community close to home is coordinated by two leading teachers who participate in the PLC workshop. The Tira community of chemistry teachers, will serve as an example to a community "close to home", which based most its activities on the action research model. The workshop was accompanied by evaluation procedures, aimed at determining whether the main objective of the action research activities was accomplished. As mentioned above, the main objective described in this paper, was: How to enhance the chances of creating a professional community of chemistry teachers in Tira?

Workshop participants. 15 teachers of the "Tira professional learning community close to home" (TPLCCH). Tira is a city in the central part of Israel, and most of the citizens are Arabs. All the 15 teachers taught in high schools around Tira, and had at least 10 years of high-school science teaching experience, mainly in grades 10–12. All of them had already participated in several in-service professional development workshops. During the workshop, they met once in three weeks, coordinated by two leading teachers (see Picture 1 below).

Picture 1. *The workshop participants.*

Characteristics of the workshop. Each meeting consisted of:

- An opening activity aimed at creating social and personal relationships among the members of the group, as well as openness and trust to strengthen the cooperation among members of the community, discussing their needs, and enabling them to gain a sense of ownership.
- "Our corner" – one or two teachers share an experiment or an interesting activity with their colleagues - a short, stimulating and thought-provoking activity that can be applied in the classroom. It can be an experiment, a demonstration, a discussion question, an interesting video clip, or a technological innovation in education.
- A discussion referring to a content and pedagogical subject, e.g., diagnostic questions, misconceptions, unclear questions, or alternative assessment methods
- Sharing lesson plans regarding new curriculum materials.
- A reflection of each teacher at the end of the meeting, referring to the meeting's topics.
- Action research activities as a platform for all the above.
- During the meetings, the teachers at TPLCCH conducted action research activities, referring to issues which bothered them. The teachers dealt with content issues as well as pedagogical issues such as: "Can we change students' attitudes toward science by integrating relevant, everyday issues into their science curriculum?" The activities consisted of: (1) identifying the general problem and their own research question, (2) planning the research including the development of the research tools, (3) data collecting and analyzing, (4) implementing, (5) data collecting and analyzing, and (6) evaluating and reflecting. The various stages are presented in Figure 2.

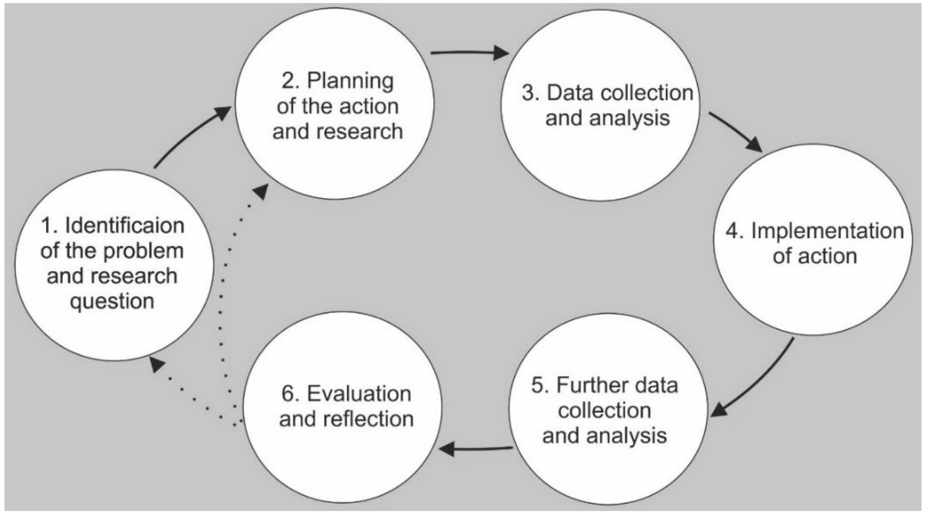

Figure 2. *The various stages of action research (Mamlok-Naaman et al., 2018)*

The following will serve as examples to action research activities, in which all the TPLCCH teachers participated.

1. Diagnosis of students' ideas and difficulties. Teachers are usually surprised to find out that their students have learning difficulties and misconceptions. Therefore, diagnosis of students' misconceptions is a very important activity. Major misconceptions have been encountered in topics such as bonding and structure, acids and bases, energy, and equilibrium. One of the activities is based on a study conducted by Ben-Zvi Eylon and Silberstein (1986). The study consisted of three stages: (1) a diagnostic investigation of students' views of structure in chemistry, (2) development and implementation of a program designed to prevent some of the misconceptions identified in the first stage, and (3) an evaluation of the new program. The diagnostic investigation of students' views of structure in chemistry consisted of a questionnaire administered to eleven 10th-grade classes in different high schools in Israel (about 300 students, average age 15 years). All students had studied chemistry for at least half a year. The question relevant to the atomic model was:

A metallic wire has the following properties: (1) conducts electricity, (2) brown color, and (3) malleable. The wire is heated in an evacuated vessel until it evaporates. The resulting gas has the following properties: (4) pungent odor, (5) yellow color, and (6) attacks plastics.

- Suppose that you could isolate one single atom from the metallic wire. Which of the six properties would this atom have?
- Suppose that you could isolate one single atom from the gas. Which of the six properties would this atom have?

Most of the teachers at TPLCCH who disseminated this question among their students reported that their students could not differentiate between macro and sub-micro concepts. The interventions which they decided upon in order to cope with the misconceptions consisted of: using models; computerized interactive programs; video clips; games, etc. The process of dealing with the misconceptions which were diagnosed, was based on the action research rationale (see above).

2. Lesson plans referring to socio scientific issues (SSI). A few lesson plans shared at the TPLCCH, dealt with issues of sustainable development, as suggested by the two leaders of the community. Issues of sustainable development have been suggested as a way to contextualize chemistry learning for relevant chemistry education (Eilks & Hofstein, 2014). If this is implemented from an SSI-based perspective (Eilks et al., 2013), controversial issues from the sustainability debate can be used to motivate chemistry learning within the context of a societal perspective. The issue of alternative fuels can be used as an example (Mamlok-Naaman et al., 2015).

In recent years, a group of teachers in Israel developed a lesson plan that was called "Can used oil be the next generation fuel?" (Ezra et al., 2012). This lesson plan focuses students' learning on traditional and alternative fuel sources. The students learn about the advantages and disadvantages of each of the different suggested technologies: fuels from crude oil, recycling of used oils, or producing biodiesel from vegetable oil.

The lesson plan uses a structure that starts with the SSI, involves learning about the content behind the issue, and then turns to questions of evaluation and reflection on the issue from different perspectives and in the foreground of the societal discourse. The lesson plan starts with exposing students to information about the world's energy crisis and its consequences. Discussion of this information activates prior knowledge and raises questions to be answered. The idea that teachers should convey to their students is that sustainable mobility is a worldwide problem and not just a scenario for the science classroom. Furthermore, there are several proposed solutions to this challenge, but these solutions often introduce new problems.

Students undertake different activities to investigate and compare the different fuel types in order to decide on various options for providing fuels for mobility. In one activity, the students are asked to inquire into the chemistry of the use of different fuel types, one of which is biodiesel. Comparative activities require students to select criteria such as enthalpy of combustion values or the release of emissions. The teacher then introduces the student to an experiment that compares the energy released by the combustion of different fuel types. By measuring the mass of the fuel needed to increase the temperature of a certain volume of water by 30 degrees Celsius, students can compare the caloric values of different fuels. They can also investigate the level of pollutants emitted from the burning fuels with a special board called the "Ringelmann scale," which determines the concentration of soot particles produced by the flame. Students are then asked to decide which is the best fuel. Before making a final decision, there is an attempt to involve students emotionally and from an ethical perspective by creating a conflict regarding the use of biodiesel. This activity is based on viewing pictures that highlight the use of crops for fuel instead of using them as a food source for the world's ever-growing population. Students' decisions should be based on arguments, but first there should be agreement within the group about the assumed meaning of the term best fuel. This discussion leads to understanding that a thorough comparison requires more criteria beyond the limits of chemical behavior. These criteria include price, environmental behavior, production methods, and societal impact. An open discussion about which technology has the most promising potential for sustainable development is used to end this lesson plan.

Within this lesson plan, the students learn about an authentic sustainability issue and the complexity of its solution. On the one hand, they learn that there is no best fuel nor any best solution to many sustainability problems. On the other, they learn that making use of used oil or biofuels is not the ideal solution. Other ways might better protect the environment because less waste is produced and fossil resources are saved. However, the students also learn how complex such evaluations are and how many dimensions need to be taken into consideration before an overall decision can be made.

The teachers who participated in the TPLCCH, conducted an action research activity about the attitudes of the students towards social scientific issues before teaching the above lessons and afterwards, in order to be able to improve the lesson plan as well as well as their teaching regarding this topic.

Data collection and analysis

Data were collected for two years from a variety of sources: video records of the teacher-leaders' PLC meetings; reflection questionnaires; e-mail correspondences; minutes taken by the coordinators during the workshops; interviews. The focus in this paper will be on the interviews and on the minutes. The analysis of the interviews and the minutes was done according to basic methods of qualitative data analysis (Glaser & Strauss, 1967; Tobin, 1995).

The interviews with the 15 participating teachers were semi-structured (30 min each), and were conducted by the two workshop coordinators, after the workshop was completed. Some of the questions were previously established by the interviewer, with a limited set of response categories (Fontana & Frey, 1998), and others were more open-ended. The interviews were audio-recorded, transcribed, and analyzed by the author of this paper according to two main categories that emerged from the teachers' answers, referring to the contribution of action research activities to:

- The creation of their community – trust, friendship, cooperation,
- Their self-efficacy in dealing with diagnostic questions and students' difficulties, or socio-scientific issues, and other innovative issues and ideas.

Minutes of the workshop meetings. One of the coordinators of this paper wrote a protocol of the discussions held during the meetings. It served as a triangulation to the analysis of the interviews. From reading the minutes of the meetings, there was a possibility to learn about the teachers' attitudes toward the action research activities as well as about its contribution to the creation of their community close to home (TPLCCH). The minutes helped to clarify the data collected from the interviews and were analyzed according to issues that revealed during the meetings.

Findings

The teachers who have participated in the PLC workshops for chemistry teachers seemed to be enthusiastic and satisfied with the workshop despite the large amount of time that they had to devote to it. The following emerged from the analysis of the interviews and the minutes:

1. The action research system helped them structure their reflections upon their work, and as a result, conduct changes in their way of teaching. Sara (pseudonym) claimed:

> *It took me some time to understand the action research methodology, but I developed it thanks to the activities in our meetings. We kept up contact through emails and exchanged information and ideas. For instance, the discussions in the course helped me define my action research question. I presented my ideas to the group and I received meaningful feedback.*

2. The action research system enhanced their ability to share teaching difficulties with their colleagues, as well as lesson plans and interesting experiments. They were encouraged to develop ownership of innovations in education, becoming more student-centered (Mamlok-Naaman et al., 2018). Debra (pseudonym)said:

> *The action research activities helped us share ideas, and this was an asset in itself. During the workshop meetings we consulted with each other, shared ideas, met other people who had the same problems I faced.*

3. The action research activities helped in improving the teaching culture: trust, ownership, friendship (Tschannen-Moran, 2014). During the meetings, a feeling of trust was developed among the participants, which enabled them to discuss and analyze their students' cognitive and affective problems, misconceptions, and learning outcomes. Rachel (pseudonym) mentioned the fact that:

> *I have a new way of teaching and dealing with problems in the classroom and reflecting upon my work. I used action research to cope with the students' difficulties. It helped me understand them better, and I believe that I can cope better with it.*

4. The action research activities improved the professional community environment, and this enhanced their self-efficacy and their ability to share teaching difficulties with their colleagues.

> *We worked together all the time and were very active. We felt that we are contributing to each other. Our self-efficacy to share teaching difficulties increased.*

Reading through the minutes of the workshop also confirmed the fact that the action research activities stimulated discussions and debates among the participants, created a deeper understanding of the what they were doing, and provided greater insights regarding the students' learning process when dealing with diagnostic questions.

The teachers seemed to be enthusiastic and satisfied with the workshop despite the large amount of time that they had to devote to it. We attributed it to several points:

- The workshop was initiated because of the teachers' requests and needs.
- The participants were excellent, experienced teachers who had very high motivation and a drive to succeed.
- The participants felt that the action research activities helped them create a professional learning community close to home, of teachers who share ideas and trust each other.

Conclusion

Based on the above, we may conclude that the teachers in the TPLCCH experienced a new process for professional development. They got new insights regarding their teaching and were able to improve and promote their classroom instruction. The topics discussed at the action research workshop enabled them to realize that being reflective has its own value and is indeed beneficial to their work. It strengthened their teamwork at the TPLCCH, and encouraged collaboration between themselves and their colleagues.

As Joyce and Showers (1983) suggested, teachers are interested in improving and enriching their teaching methods, and action research in particular has been a new experience for those teachers who participated in the workshop. The teachers were enthusiastic, but still inexperienced in conducting reflections and revise their teaching accordingly.

The workshop provided an environment of support, collegiality, and collaboration with other teachers who teach the same or related subjects, in a milieu that encourages teachers to reflect on their classroom practice and on the results of their research efforts. All the teachers were very enthusiastic about the fruitful discussions during the workshop, and claimed that the workshop contributed a lot to their work and to their ability to find solutions to their problems. In addition, they became more concerned about improving their practice and learned how to share their ideas and experiences with their colleagues.

It is suggested, that the teachers in this particular TPLCCH gained a sense of ownership regarding the program due to their personal contribution to the activities, and their self-efficacy increased. In addition, we believe that the PLC meetings had an impact on teaching practices, and served as a perfect environment for preparing and encouraging teachers to conduct changes - towards gaining pedagogical content knowledge in conveying important issues in education, and preparing the future citizen in a mixed cultural society.

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