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CHEMISTRY TEACHERS' PROFESSIONAL DEVELOPMENT FOR THE IMPLEMENTATION OF NEW CONTENT AND PEDAGOGICAL STANDARDS

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Introduction

New standards in science and mathematics education in general and in chemistry education in particular are being advocated, standards which reflect the current vision of the content, classroom environment, teaching methods, and support necessary to provide a high quality education in the sciences for all students (NRC, 1996). In the past, conventional methods of conducting pre-service and in-service education and professional development have not always proved to be adequate for attaining such demanding goals. In-service workshops conducted all over the world have been usually too short and occasional to foster a change in teachers' classroom practice. In order to meet the challenges of reform in science education we need to help schools and other educational institutions, that are involved this reform, to meet the challenges of the times. One of the ways to attain these goals is to treat teachers as equal partners in decision making. In other words, teachers have to play a greater role in providing key leadership at all levels of the educational system. Leadership in the context of science education was defined is the ability of a person to bring about changes among teachers and teaching. Pratt (2001) suggested that that there are four basic skills relevant to effective leaders in science education (in our case chemistry), namely; (1) technical skills, (2) conceptual skills, (3) interpersonal skills, and (4) self-learning skills.

Developing Leadership among Chemistry Teaches in Israel

Reform in Science Education

In this paper, I describe an innovative program developed in Israel (at The *National Center for Chemistry Teachers*, The Weizmann Institute of Science), whose aim was to improve the pedagogy of chemistry education in the Israeli educational system. It focuses on a model aimed at the professional development of chemistry teacher-leaders. Israel has a centralized education system. The syllabi and curricula are regulated by the Ministry of Education. Since the 1960s', the Ministry of Education has provided for the long-term and dynamic development of science curricula and its implementation. These initiatives were usually accompanied by short courses (summer schools) for science teachers in general and for chemistry teachers in particular, intended to introduce them to the new approach and its related scientific background. These courses were usually conducted at science teaching centers located in several academic institutions throughout the country as part of the *Israeli Science Teaching Center*, the central consortium of science curricula

development and implementation.

In 1992 the 'Tomorrow 98' (1992) report on reform in science, technology, and mathematics education was released. The report includes 43 recommendations for special projects, changes, and improvements, both educational and structural, in the area of curriculum development and implementation, pedagogy of science and mathematics, as well as directions and actions to be taken in the professional development of science and mathematics teachers in general, and the development of leadership among teachers in particular.

More specifically, the report recommends:

- Providing science teachers with the opportunity to engage in life-long-learning.
- Creating an environment of collegiality and collaboration among teachers who teach the same or related subjects, an environment that encourages reflection on their work in the classroom.
- Incorporating the process of change into professional development (support for these goals can be found in Loucks-Horsley, Hewson, Love, & Stiles, 1998).

In order to attain these goals, national and regional centers for the professional development of science and mathematics teachers were established (for more details, see Hofstein & Even, 2001; Hofstein, Carmi, & Ben-Zvi, 2003). The overriding aim of these centers is to enhance educational reform by providing a strong framework for the development of teachers. These national centers are, among other activities, responsible for the development of science teacher-leaders (in our case chemistry teachers) who are expected to initiate, plan, and implement long-term professional initiatives in both their schools as well as in professional development regional centers around the country.

Content and Structure of the leadership program

The program was planned with the assumption, that the participants (chemistry teachers) are thoughtful learners; that they are prepared to be professional teacher-leaders; that after completion of the program the teachers will develop creative strategies for initiating reform in the way chemistry is taught, and in professionalizing other chemistry teachers. Consequently, it was decided to design the program around the following three components:

- Developing the teachers' understanding about the current trends of chemistry teaching and learning to include both the content and pedagogy of chemistry learning and teaching; For example, currently with the trend to make chemistry more relevant it is suggested that new programs in chemistry should include in addition to the conceptual approach and the process of chemistry also its societal and personal applications, technological manifestations, and those components that could be characterized historical and nature of chemistry (nature of Science) (Kempa, 1983).
- Providing the teachers with opportunities to develop *personally*, *professionally*, and *socially* (Bell & Gilbert, 1994).
- Developing leadership among these teachers and enhancing their ability to work with other chemistry teachers.

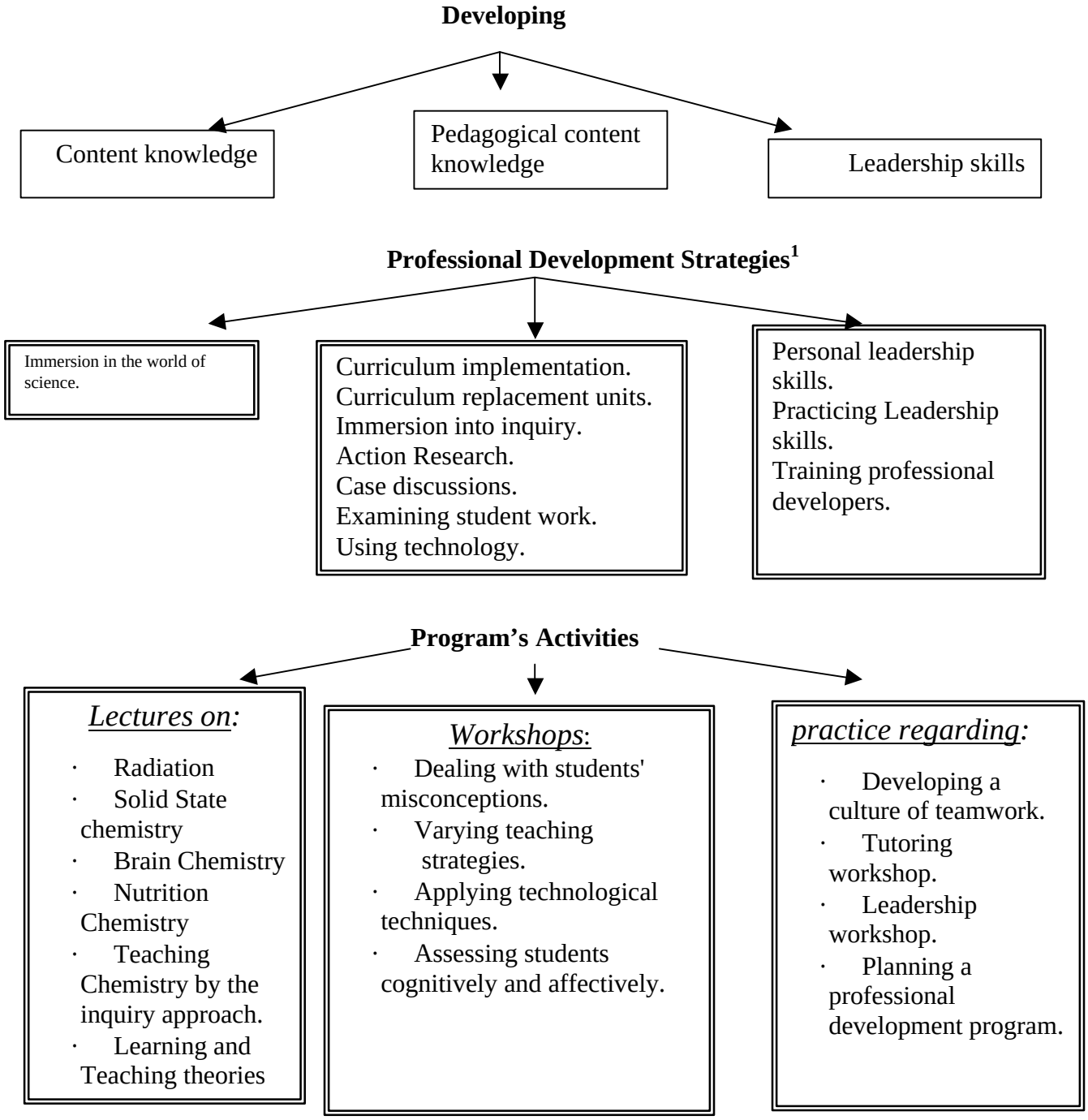

Figure 1: Structure of the leadership course

[1] Based on Loucks-Horsley et al. (1998)

The program extended over a period of two academic years, totally 450 hours, conducted one day a week, in an effort to allow for the gradual development and growth of the participants' conceptions, beliefs, and changes in behavior. In other words, to allow enough time for the development of teachers *personally, professionally,* and *socially*. The first year of the program was mainly devoted to the development of the teachers' *content knowledge* in various topics in chemistry that characterized as relevant to the learners, posses a historical background, and also has a technological ramification and application. Among these topics are: forensic chemistry, solid-state chemistry, the chemistry of nutrition, and selected topics in the area of interaction between radiation and matter. In addition, a large segment of this year was devoted to the development of the chemistry teachers' *pedagogical content knowledge*. The second year was mainly devoted to the development of skills in the area of leadership. The various abilities and skills were developed using many of the strategies for professional development suggested by Loucks-Horsley et al. (1998) and are presented in figure 1.

The program for chemistry teacher-leaders was designed to include all the necessary components that comprise the life-long professional development of science teachers, and also those components that are unique to the development of leadership among chemistry teachers.

Assessment of teachers' changes resulting from the leadership program

The assessment of the development of leadership among the chemistry teachers focused mainly on the following three interrelated variables:

- Development of their *personal* beliefs about themselves, about teaching chemistry, and about becoming a leader;
- Development of their *professional* behavior and activities in their chemistry classroom (mainly development of the teaches' *pedagogical content knowledge*);
- Development of leadership skills, and activities involving other chemistry teachers in and outside their schools (the teachers' development *socially).*

Throughout the program, and a year after the chemistry teachers who participated in the program (N=19), were assessed continuously in an attempt to obtain information regarding these interrelated variables. In order to increase the validity of the assessment triangulation method was used namely, a combination of both qualitative (interviews, observations, and protocols on the meeting) and quantitative strategies (mainly feedback questionnaires, and questionnaires administered among the teachers' students in school) and tools.

Based on the various components of the assessment of the program we have evidence that at the end of the program, the program's participants had grown *professionally, personally, and socially.* Such growth could be detected in the participants' reports and feedback questionnaire and interviews that were conducted with a sample of the participants throughout the program. In addition, based on our observations, it was clear that the teachers developed useful social skills and habits. These were developed through small group collaborative discussions and debates on issues regarding students' learning ideas relating to the teaching of chemistry as well as the professional development of other chemistry teachers (ideas about planning

and conducting chemistry workshops and courses).

It was observed that in entering the program, most of teachers did not consider them selves as leaders rather than school chemistry teachers who learn to become better teachers. Only gradually through enhancing their content knowledge and through the opportunities to develop their *personal, professional,* and *social* abilities they started to admit that they are ready to embark on duties that will involve them with activities in which leadership is required. In addition, we found that towards the end of the program, as a result of intensive guidance and involvement in professional development activities, there was a significant enhancement in the teachers' internalization of the main goals of the leadership program. These developments could not have occurred without the teachers being provided with experiences that aimed at enhancing their chemistry *content knowledge* and *pedagogical content knowledge*. During the program, the teachers were provided with numerous and varied types of opportunities to develop their chemistry knowledge, teaching and assessment skills, as well as general science education skills. In addition, they were given opportunities to plan and develop learning materials, develop instructional activities and pedagogical interventions with the goal in mind to vary the classroom learning environment and as a result to enhance the students' interests in chemistry and their motivation to learn chemistry. In addition, they were provided with opportunities to develop alternative assessment tools that will enable them to implement them in their classrooms and in the chemistry classroom of their peers to whom they are responsible. During the program, using action research (in which teachers research their own classroom) activities, the teachers had opportunities to assess the impact of the newly developed learning material and pedagogical interventions on their students' learning attitudes, and behaviors.

Information regarding the teachers' classrooms learning environment was obtained by probing into their chemistry students' perceptions by using paper and pencil measures developed throughout the years in the context of science curricula development and implementation (Fraser, 1998). In this study the classroom LEI (*Learning Environment Inventory)* was used. The study revealed a significant change in several dimensions that shape the chemistry classroom learning environment. More specifically changes were revealed in the following dimensions:

- The rate *(speed)* of the instructions in classroom was significantly reduced.
- The *friction* among students in the class was significantly reduced.
- The students' *satisfaction* regarding their experiences in the chemistry classroom has significantly increased.
- Increase was observed in the students' perceptions in the scale assessing the *goal-direction* (the extent to which the objectives of learning chemistry are clear).

It is suggested that these changes were as a result of the experiences provided for the chemistry teachers in the leadership program. Support for the findings regarding changes in students' perceptions of the chemistry classroom-learning environment was revealed by the feedback questionnaires gathered from the teachers. In these questionnaires the teachers reported on an increase in making chemistry more interesting for their students, in their improved ability to cope with students' learning

difficulties (by using diagnostic tests, for example) and in varying the type of instructional techniques that they adapted for use in their classrooms. Clearly, the experiences that the teachers had in the program enhanced their confidence to try new ideas in their classroom and to better plan their activities.

The third component of professional development, based on Bell & Gilbert's 1994 model, is the social component. Social development involves learning to work with other people in the educational system in new ways. It is suggested that in order for teachers to develop socially they need to have a strong and solid professional foundation. This is the case since many of the activities that were used in order to enhance the teacher professionally involved the teacher working with others in the program and later on in their schools. The teachers were given opportunities to work with others in the program since most of the work was conducted cooperatively in small groups. In addition, in the second year the participating teachers started to coach and mentor the team of chemistry teachers in their school. From the feedback questionnaire administered to the participating teachers and on the basis of the interviews held throughout the program, the teachers reported an increased intensity of working with other teachers in their schools. These professional development strategies were similar or identical to those that were used in the leadership program.

Summary and Concluding Remarks

A long term and intensive program was provided for 40 chemistry teachers in *Israel*. The main goal of the program was to develop teacher leaders that will support and help to attain goals of reform that is taking place in Israel. The reform in chemistry education in Israel is characterized both in the content of chemistry as well as in the pedagogy of chemistry namely in the instructional techniques and learning methods implemented in the chemistry classroom in order to make the classroom learning environment more educationally effective. The model that was adopted for this study was the one developed by Gilbert and Bell (1994) in New Zealand. They suggested that science teacher development is viewed as professional, social, and personal development and that teacher development programs and activities should address these three interrelated components. The professional development program described in details in this paper was developed with the goal in mind that change in these three aspects will occur. The results of the assessment of the teachers' development throughout the program provided some evidence that the experiences and content provided for the chemistry teachers through the various professional development strategies used in the program aiming at enhancing the teachers', '*content knowledge', 'pedagogical content knowledge',* and leadership skills were effective in the development of the teachers in this three professional domains. In regard to teachers' development at the *personal* level we presented evidence (from both the quantitative sources as well as from the qualitative sources) that as a result of their experiences, the teachers developed affectively. This development involves attending to feelings about the change process they underwent, about their feelings regarding change they underwent as chemistry teachers, and finally the increased confidence (over time) regarding the idea that they might become leaders in chemistry education. *Professional* development relates mainly to the teachers development in the content of the subject matter they teach and to the relevant pedagogical content knowledge. Evidence on this component were gathered from

students perceptions of the chemistry classroom learning environment as well as from the teachers self-reports regarding changes they underwent which they applied in their practice in their classroom in their own schools, and in out-of-school activities namely in the science teachers' professional development centers. Finally, the teachers had many opportunities to enhance their *social* skills through collaborations and cooperation with their peers in the program, through working with the team of chemistry teachers in their own schools, and in a later stage in the professional development activities as tutors in professional development programs.

In conclusion it is suggested, that this study provides information regarding the validity of the Gilbert and Bell's (1994) model for the professional development of chemistry teachers in general and chemistry teacher-leaders in particular. Until the '90s most of the efforts in trying to achieve the desired changes in school science focused on the development of improved science curricula. In the last decade, however, more attention has been gradually given to the teacher, since past efforts in educational reform suggested that the teacher plays a critical role in the ways new ideas are created in the classroom. Thus, it was realized that the teachers' need to learn to teach in new ways should not be ignored. Consequently, changing the in-service work with teachers was required. The establishment of regional teacher centers created a comprehensive framework that can provide opportunities for in-service teachers for life-long learning in their profession. Achieving scientific literacy for all has become a national goal for education in many countries. Although admirable, this goal represents a challenge for science teachers and for those responsible for professional development. Achieving this goal must be accompanied by a reform in the way science in general and chemistry in particular is taught in schools and in the methods that are used to make chemistry teachers more professional. To date half of the teachers who participated in the program serve as tutors and guides in the area of chemical education. About 10 teachers who graduated from the leadership course started graduate studies in chemistry education.

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