PROFILES

Professional Reflection Oriented Focus on Inquiry-based Learning and Education through Science

January 27, 2013

PROFILES – WP6: The Development of Teacher Ownership

Guidelines for promotion of teacher ownership related to the teaching of PROFILES modules

Lead Partner of work package 6: Weizmann Institute of Science

Report compiled by: Avi Hofstein and Rachel Mamlok-Naaman

Rehovot, 76100, Israel, January, 2013.

SEVENTH FRAMEWORK PROGRAMME – 5.2.2.1 – SiS-2010-2.2.1
Supporting and coordinating actions on innovative methods in science education: teacher training on inquiry based teaching methods on a large scale in Europe
Grant agreement no.: 266589

.Introduction: What is teacher ownership of PROFILES?

Section of B 1.3iiid6 wp6 of the PROFILES document deals with ownership: *Teacher ownership of I BSE teaching, the description of work consists of: This work package will enable teachers, supported by teacher teams, to sustain their reflective best practices and introduce in their reflective models, e.g., action research, or evidence-based professional development workshops, focus groups workshops with scientists. As an important component of the intervention, the teachers, working with the teacher teams who provide inter-teacher support, provide feedback on their reflections and practices in successfully moving towards teacher ownership.*

The following document aims at aquatinting partners and their professional development providers with the theoretical background of teachers' ownership, its development via the PROFILES CPD program, and methods of assessment of the development of these characteristics.

In recent years, science curriculum developers realized that one of the key factors regarding the effective implementation of science curricula is the active involvement of the teachers in the process of designing and development, and implementation of learning materials and their related instructional tools (pedagogies) (Bennet et al, 2006; Rannikmae, 2005; Ogborn, 2002). This is the case also for the PROFILES project where a two key stages development is put forward: Tthe first, self- of PROFILES ideas by means of CPD involvement; second teacher ownership of PROFILES by undertaking evidence giving activities. Ogborn (2002) in the UK, for example in his essay regarding involvement of teachers in curricular innovation, concluded that:

> One of the strongest conclusions to come out of decades of studies of the success and failure of a wide variety of curriculum innovations is that innovations succeeded when teachers feel a sense of ownership of the innovation: that it belongs to them and is not simply imposed on them (pp.144).

A curricular approach in which the teachers are actively involved in this process is fondly called the "Bottom-up" approach as opposed to the traditional "Top-down" approach (Blonder, Mamlok-Naaman, & Hofstein, 2008) that prevailed for many years in the western countries, e.g. the 1960s' and early 1970s' in the USA (The Golden age of curriculum development Bybee, 1997 and the UK in the various Nuffield projects, Waring, 1979). The bottom-up approach is an essential feature of

PROFILES and is usually promoted through the CPD programme and the intervention in which teachers utilise PROFILES modules and promote PROFILES ideas in the classroom.

Teacher *ownership* beyond the PROFILES CPD (continuous professional development)

Bandura (1997) defines self-efficacy as: "Beliefs in ones capabilities to organize and execute the course of actions required to produce given attainments." (p.3). It is suggested, that in order to develop a sense of self efficacy among teachers, it is vital to develop the teachers as learners and as practitioners in their classroom. This is done through the various CPD programs initiated and conducted by the partners and their related CPD providers. In other words, the self-efficacy goal should be to equip the teachers with the relevant CK - content knowledge (in PROFILES the scientific content and its related social applications) and the aligned PCK (pedagogical content knowledge). The PCK for example, includes the skill of teaching based on the PROFILE's 3 stage model linked to student motivation, IBSE and decision making, and the PK (pedagogical knowledge) relates to, for example, teaching and learning in small collaborative groups.

Two developments, namely the *teacher as learner* and the *teacher as teacher* (see Figures 1 & 2), are the initial and basic components in the four stage CPD model that is used in the PROFILES project. It is suggested that the 2nd stage, in which the teacher is involved in the *development or adaptation* of the module, and the 3rd stage, namely the *teacher as a reflective practitioner*, are essential stages in which sense of *ownership* starts to be developed in the teacher's mind. This includes face to face meetings and – in some cases additionally – on line discussions. The PROFILES CPD approach (using different CPD models developed by others in various projects (see for example Loucks-Horsley, Hewson, Love, & Stiles, 1998) provides the teachers with ample opportunities for reflection on their experiences regarding the adaptation, development, and implementation of PROFILES modules. We assume that the initial stages in which ownership is developed are those in which the teacher starts to develop or adapt, and then implement the module in their respective classroom. This continues for those teachers going to the blue stage in the CPD model below in which the teachers are guided to take ownership of PFOFILES and provide meaningful evidence for this.

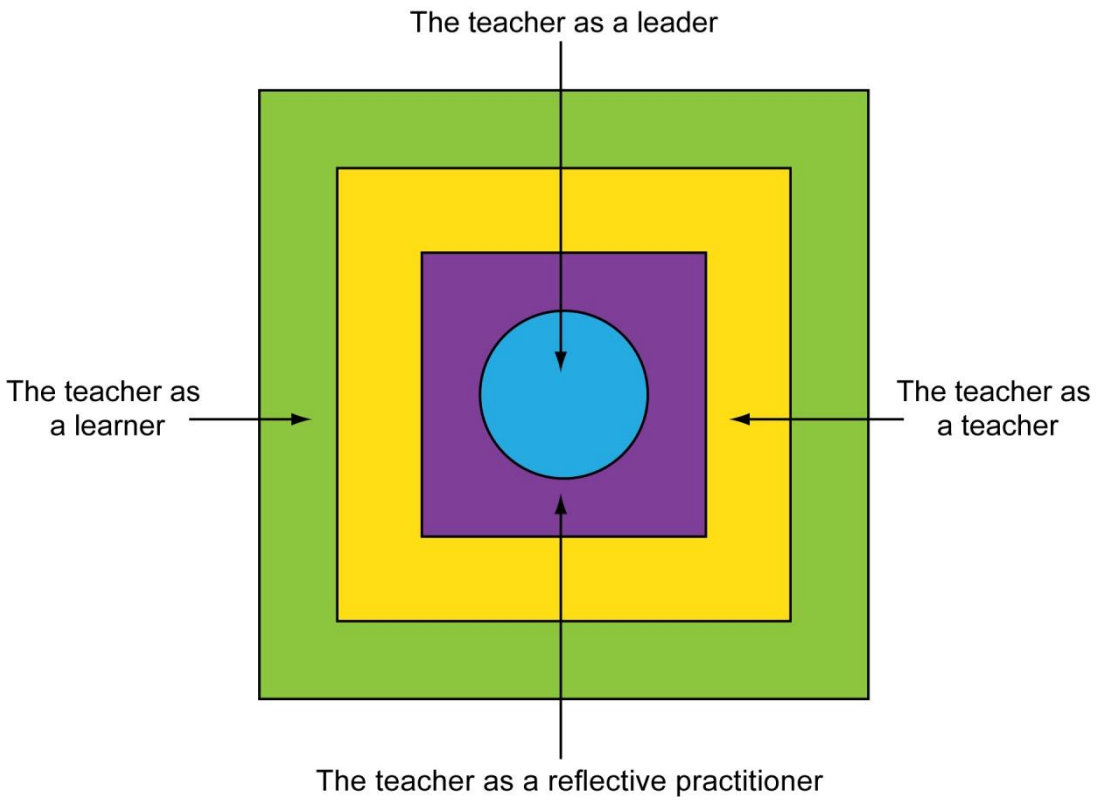

Figure 1: The PROFILES' Continuous Professional Development components

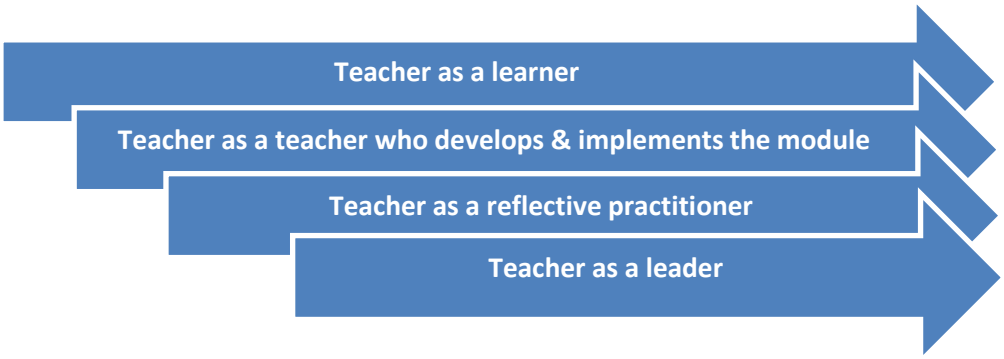

Figure 2: Another suggested model. (This figure, it is suggested, represents a more dynamic idea).

In the PROFILES project it is expected that different partners are using different CPD models and approaches to enhance the teachers' professional status. While the generic model above provides the 4 major components, partners will base their model on: teachers' needs, the educational (and also

economical) conditions in the partner country, and the style of CPD provided. Loucks-Horsley, Stiles, and Hewson (1996) suggested six key principles for effective CPD experiences that should be provided for science teachers. These experiences:

1. Are driven by a clear, well defined image of effective classroom learning and teaching. Among other factors they emphasis on inquiry-based learning, students' investigations and discovery, and application of knowledge.
2. Provide teachers with opportunities to develop knowledge and skills and broaden their teaching approaches, so that they can create better learning opportunities for students.
3. Use instructional (pedagogical) methods to promote learning for adults to mirror the methods to be used later by their students.
4. Provide condition to learn in a community of practice (promotion of collegiality and collaboration). Also providing support for each other. In addition, CPD is viewed as lifelong process that is part of school norms and culture.
5. Prepare and support science teachers to serve (at least part of them) in leadership roles if they are inclined to do so. The meaning of leadership in this context is highly aligned with the claim made by Fullan (1991) regarding: "The ability of a person to bring about changes among teachers and teaching".
6. Include assessment. CPD programs must constantly be assessed and reviewed regarding engagement, satisfaction, etc.

Clearly, the first three principles are related to the first two stages mentioned above, namely the *teacher as a learner* and the *teachers as a teacher*, while the other three are highly related to the teacher as a reflective person who enhanced self-efficacy and ownership. It is suggested that the CPD models (implemented in the PROFILES project) that are designed according to these principles have high potential to develop teachers' ownership in the PROFILES CPD program. It is suggested, that using PD models in which teachers are involved in the development of the PROFILES modules in which the teacher acts as a *curriculum developer* and in *action research* (see Appendix 3) in which the teachers are involved in assessing their own classroom learning environment . These activities provide opportunities to develop self-efficacy and sense of ownership.

Evidence for establishing PROFILES ownership

In addition to the ability of teachers to reflect on their practice, we (The Weizmann Institute of Science team) have observed and identified other variables that indicate the development of a sense of ownership, namely:

- The willingness to involve other teachers in school in the project
- The willingness to identify socio-scientific issues (to be developed) that has a local characteristics (e.g. an environmental-type issue) looking for a relevant issue.
- Identifying themselves with the rationale of the project (development and implementation).
- Identifying oneself with the newsletter (published on the web)
- Involving the principal in the project (stake-holders).
- Telling your student that you were involved in the development or adaptation of the module as a part of international project.
- The dissemination of the project or module to other teachers
- Teachers make an attempt to bring items (artifacts) that eventually will provide evidence for their classroom behaviour and practice.
- When teachers perceive that the topic or issue taught is relevant to his/her classroom (the nature of the students)
- When teachers decide to make changes, alternations, and amendment to the original module. This is highly based on their self-reflections (see Appendix 1).
- The willingness and ability of teachers to bring evidence for their accomplishment (see Appendix 2).
- Their willingness to serve as leaders in the 2nd year CPD program (2012- 2013 academic year)

It is suggested that these observations and indications for ownership could be categorized as under the following five categories:

Category A: Feeling empathy towards the project and believe in its rationale

Category B: The promotion of the teacher's status among peers.

Category C: Promotion of the teacher's status in his/hers classroom.

Category D: Feelings regarding involvement in the various stages of the modules development

Category E: Feeling related to the involvement in the CPD program.

In practice' the following examples show evidence of ownership among teachers in that was observed in the Weizmann Institute CPD (please note that these are only examples)

a. A groups of PROFILES teachers provided information related to the design and implementation of their modules in class in a national meeting of chemistry teachers. All projected their enthusiasm to other teachers.
b. Teachers published articles for teachers about their experience in the design and implementation of their modules
c. One teacher reported on the PROFILES success story in overcoming obstacles using *action research* (see Appendix 3).
d. L. was proud to show her students' portfolios at a teacher conference/meeting (see Appendix 4)
e. B. told her class about them taking part in a European project PROFILES and her being part of the networking to encourage teachers.
f. S.'s students asked her to develop a module on ice cream on the beginning of the second school year, and part of them asked to continue their work on sunscreens a module which they experienced in the following school year.
g. Bo. convinced two teachers to join PROFILES in the second year, he himself joined once again.
h. Six teachers joined PROFILES in the second year, and their feedback (face to face and on-line) provides evidence for their ownership and enthusiasm for PROFILES.

Assessing the development of ownership

There several ways that one can use in order to assess the development of a teacher's 'sense of ownership'. In addition to the ability to reflect on their practice, we have observed (and identified) variables that indicate how the teachers developed a sense of ownership, e.g., analysis of the written and oral reflection of the teachers or other kinds of communication which enable us to identify characteristics of ownership (See Appendices 1 & 2).

What is leadership in the context of science education? The development of science teachers' leadership

Teaching science effectively in the classroom requires much more than just a straightforward implementation of the curriculum. One of the most promising and effective methods to attain the goals of reform (changes the way science is taught and learned) and to enhance professional development is to develop leadership among science teachers (Hofstein, Carmi & Ben-Zvi, 2008; Pratt, 2001; Fullan, 1991). Leadership in the context of education was defined by Fullan as: "The ability of a person to bring about changes among teachers and teaching". Bybee (1993) suggested a model which defines the characteristics of the science leading teachers' personal qualities namely: motivation, integrity, self-confidence, responsibility, creativity, and adaptability. These characteristics are very much in alignment with the characteristics of ownership described above.

According to Pratt (2001) in the context of the National Science Education Standards in in the USA (NRC) suggested that there are four basic skills relevant to effective leaders, namely: (1) technical skills, (2) conceptual skills, (3) interpersonal skills, and (4) self-learning skills. It is assumed that the PROFILES' CPD programs provide science teachers with opportunities to develop these skills through teachers' active involvement in the PD process. Clearly, CPD models such as *Teachers as curriculum developers* and *Action Research* may provide opportunities to develop self-efficacy, ownership and as a result, leadership.

Loucks-Horsley, Hewson, Love, and Stiles (1998) suggested a list of roles for leading teachers regarding professional development. It is suggested that some of these roles could potentially be adopted in the context of the PROFILES project:

- Leading teachers can conduct professional development for other teachers either in their own schools or in teachers' centres (national or regional). In addition, they might serve as coaches for novice groups of teachers.
- As a result of their professional development (and enhancement of ownership) they can play role in curriculum development and implementation. Again it can be conducted in the context of schools, regional PD centers, or national-based initiatives.
- Leading teachers can provide (initiate) change in the school learning environment. This can include new instructional techniques (with the goal in mind of varying classroom practice and learning environment), new learning materials on which the PROFILES philosophy is embedded. Clearly, the PROFILES provide teachers with new pedagogies (IBSE, decision

making) new organization of learning (small collaborative group discussions) and fresh approaches for educating students through science.

It is assumed that few of the teachers who are involved in the PROFILES' CPD program and who developed several ownership characteristics, will eventually become leading teachers.

To sum-up, it is assumed that teachers who develop high level of ownership may develop the ability to become leading teachers who would in the future initiate more CPD programs: In their schools, and in regional and national teachers' centers. In 2014 the PROFILES' project will terminate. To ensure continuation of the project there is a vital need to develop leadership among PROFILES' teachers to take over the professional development of more teachers. Based on the PROFILES proposal and its related objectives we assume that about (at least) 5% of the teachers who are involved in the CPD program will demonstrate the development of a significant sense of ownership, thus, in the second cycle of the CPD program will act as leading teachers supporting new teachers who are novice in the PROFILES program. In addition, we also believe that after the termination of the PROFILES project, in each country there will be few experienced teachers (leading teachers) who might keep the "fire on the torch". In other words, to ensure that PROFILES will remain a long lasting and sustainable pedagogical idea.

References

Bandura, A. (1997). Self-Efficacy: The *exercise of control*, New –York: Freeman.

Blonder, R., Mamlok-Naaman, R., & Hofstein, A. (2008). Increasing Science Teachers ownership through the adaptation of the PARSEL modules: A "bottom-up" approach, *Science Education International*, 19(3), 285-301.

Bybee, R. (1993). *Reforming science education.* New-York: Columbia University Teaching Press.

Bybee, R (1997). The "Sputnik Era": Why is this educational reform different from all other reforms? A symposium reflecting on Sputnik: Linking the past, present, and future of educational reform. Washington DC: National Academy of Science.

Fullan, M, G. (1991)). The meaning of educational change. In M. G. Fullan (Ed.). *The new meaning of educational change* (pp. 30-46). New York: Teachers' College Press.

Hofstein, A., Carmi, M., & Ben-Zvi, R. (2003). The Development of Leadership among Chemistry Teachers in Israel, *International Journal of Science and Mathematics Education*, 1, 34-65.

Loucks-Horsley S., Stiles K., & Hewson P. (1996). Principles of Effective Professional development for Mathematics and Science Education: A Synthesis of Standards. The National Institute for Science Education (NISE) Briefs. Volume1 (1). Retrieved from:

http://www.wcer.wisc.edu/archive/nise/publications/ Briefs/ NISE_Brief_Vol_1_No_1.pdf *(Note that this publication, is highly recommended for OD providers and also teachers).*

Loucks-Horsley, S., Hewson, P., Love, N., & Stiles, K. (1996). Designing professional development for teachers of science and mathematics. Thousand Oaks California: Corwin Press Inc.

Mamlok-Naamn, R., Hofstein, A. & Penick, J. (2007). Involving Teachers in the STS Curricular Process: A Long-Term Intensive Support Framework for Science Teachers. *Journal of Science Teachers Education*, 18(4), 497-524.

Ogborn, J (2002). Ownership and transformation: Teachers using curriculum innovations. *Physics Education*, 37(2), 142-146.

Pratt, H (2001). The role of the science leader in implementing standards-based science programs. In J. Rohton., & P. Boweres (Eds.), *Professional development, leadership, and the diverse learner*. Washington DC: NSTA Press.

Rannikmae, M. (2005). Promoting science teachers ownership through STL teaching, *Asia-Pacific Forum on Science Learning and Teaching*, 6(1) (June).

Waring, M (1979). *Social pressure and curriculum innovations: A study of the Nuffield Science Teaching Projects*. London: Methuen Young Books.

Appendix 1: The teacher as a developer of a module and a reflective questionnaire - indication for the development of ownership regarding PROFILES.

The Development of a module on: "Sun Screen Ointment"

B.H.: *High School chemistry teacher who was involved in the academic year 2011-2012 in the 1st PROFILES CPD.*

He wrote a reflective essay (written in his own words):

I came to the course (CPD) on PROFILES with little knowledge about its goals and content although I had some information about the professional development providers.

For me, as a teacher, my values are: involvement, collaborations, and creativity. I sincerely believe that values are the driving forces that shape our behaviour in many areas.

I was glad to hear that the PROFILES project will provide me with experiences to develop as professional teacher (as well as my peers). From my experience in the CPD, I can say that my active and personal involvement in the project enabled me to develop as an active participant and as a result to develop me personally to become a leading teacher.

The 1st meetings in the summer course, was enthusiastic based on three reasons:

1. I had an opportunity to meet with colleagues who were involved with me in another long-term CPD
2. I mate new teachers with new ideas
3. I felt that the tutors are making their utmost to provide support and interesting pedagogical interventions.

All these motivated me to become highly involved (also in the future) in the PROFILES project.

The Selection of the topic (Sun screen ointment) was a direct result from the lecture on the importance of relevance in science education that was presented by the science education department staff.

I and my group (while thinking about the topic) were convinced that it has potential to implement the philosophy and theoretical background of PROFILESW namely: inquiry, relevance, decision making, etc.

We started the development of the module by planning and developing the framework of relevant posters. This activity enabled the active involvement of the whole group. To include, both "hands on as well as minds on". Personally I believe that this is a vital stage in such developments.

The group's collaboration throughout the year that included many communication skills (argumentation, communication, providing feedback to each other, etc.) was enjoyable and interesting experience for all the group members.

Half way the academic year I started to implement the module in my own classroom (in school). This followed the implementation of the module in another school (by another member of the group) I had the opportunity to be involved in this implementation. My impression was that the implementation of the module was very relevant to the students both regarding the varied type of pedagogical interventions as-well-as its educational effectiveness.

For me, the challenge was the writing of the learning material it underwent several cycles of rewriting and changing. Surely, my experience with teaching gave me ideas as to how to change the content and structure of the module.

In addition, preparing the abstract and poster for the Berlin's PROFILE meeting was an easy task following the experience I accumulated throughout the CPD program (the academic year).

To sum-up, I am very satisfied with the results to include the high level of the module and its alignment with the PROFILES goals.

The next assignment is to disseminate the module to more teachers in more schools. Personally I want to be involved in such an initiative. I hope the participating in the Berlin meeting will provide me with more ideas and more possibilities.

A structured reflective oriented questionnaire *(note that this is only an example).*

*What did I like most about this activity:_____

*It succeeded since I:_____

*Difficulties that I encountered during this activity:_____

*The reasons for the difficulties were: _____

*How did I cope with these difficulties? _____-

_____

* How would I cope with such difficulties in the future?_____

* Did I reach my goals in performing this activity? _____

* If so, which of them were reached? _____

* If not, why?_____

*How did the activity contribute to the students' comprehension/understanding of the content?_____

_____

*What were the concepts associated with the curriculum that were used in this activity?_____

If I will conduct this activity once again I will make the following changes:

_____

:_____

*This activity improved my skills as a leading teacher of inquiry-based learning

No, since: _____

Yes, since: _____

Appendix 2: Evidence-based continuous professional development

The rationale of an evidence-based professional development is based on the premise that in order to advance the educational system and improve the practice of teachers, it is essential to promote teachers' professional dialogue and reflection on their practice based on evidence. Such a CPD program is focused on a set of characteristics and protocols individuals can use to demonstrate evidence-based accomplished practice in science teaching. In the Following section there are some suggested activities for such a professional development workshop with teachers:

Development of the concept of evidence and its structure, based on the teacher's presentation: Ask one of the teachers to present his / her artifact. Ask the teachers to analyse the artifact according to instructions that you will give them. Following is an example of such an activity sheet.

Analysis of the teacher's presentation regarding evidence brought to the CPD: Refer to the following questions:

1. Why did the teacher choose to show this particular artifact?
2. What was the most impressive thing in this evidence?
3. How can this evidence be improved?
4. Construct together with the teachers an "Evidence template".

Evidence Template

Presenting evidence is an effective vehicle for discussing different issues from the classroom. We felt that a community of practice was developed during this CPD program. The teachers were eager to share their experience, knowledge, insights, and ideas.

It is recommended that in the teacher's portfolio each of the presentations of evidence regarding the professional development should include the following:

- *Objectives* - What does it show about my teaching and/or about my students?
- *The operating framework* - Details about the setting (context) – description of the class, the students, the subjects taught before and after the activity that is presented in this evidence.
- *Description of the activity* - The way of teaching, the teaching strategies, the models used in lessons, the grouping of students, etc. Note that it is important to attach activity sheets given to the students during the activity.

- *The Selected artifacts* - They can consist of unit plans of instruction, students' worksheets, student homework, tests, interviews, questionnaires, video-tapes of a lesson, etc.
- *Data Processing and Analysis* - The methods used, the findings, and the related conclusions.

Reflective summary – A commentary regarding the extent that the objectives were accomplished, comments about the activity, what I would do differently next time, and its significance to my work.

What can be used as an artifact from class?

Here is a list of potential artifacts that you can collect from your class:

- Videotape recorded during an activity
- Documentation you made on one of the students' groups
- Interviews you conducted with students
- Lesson plans that you prepared for the activity
- Feedback you received from a peer teacher
- Students' writing of their observations throughout the year, together with documentation of your intervention to improve it.
- Classification of students' questions (not necessarily inquiry-type questions)
- A questionnaire you gave to your students
- Documentation of subject matter you taught by using the inquiry approach versus the previous way of teaching.

Examples

1. ***"Regarding me as a teacher"***
   - To show my reasoning in dividing the students into groups
   - To show the progress I made while conducting a discussion with the whole class
   - To show the actions taken to promote students' general questions concerning the experiment, the inquiry question, and the hypotheses they made
   - To show how I integrate inquiry into the class and not only in the laboratory
   - To show how I identify students' problems in writing observations by not distinguishing between describing the procedure of the experiment and its observations

2. ***"Regarding my students"***
   - To show how my students made progress and can distinguish between describing the procedure of the experiment and its observations
   - To show how my students made progress in asking inquiry questions
   - To show how the way of dividing the students into groups (homogeneous or heterogeneous) influences the progress of different students in certain inquiry skills

Reflection: What have I learned by bringing a piece of evidence?

- What did I learn?
- In what way did I become more professional?
- What did I learn by working on pieces of evidence?
- Which piece of evidence is the best in my opinion?
- What are my next challenges in this area?
- In what way would I like to develop professionally in the future?

References (for further reading)

Loucks-Horsley, S., Hewoson, P., Love, N., & Stiles, K. E. (1998). *Designing Professional Development for Teachers of Science and Mathematics*. Thousand Oaks, CA: Crowin Press.

Osborne, J., Erduran, S. & Simon, S. (2004). *Ideas, evidence and argument in science*. In-service Training Pack, Resource Pack and Video. London: Nuffield Foundation.

Appendix 3: Action Research

Action research is an inquiry in which teachers research their own work and their students' learning in the classroom (Feldman & Minstrel, 2000). According to Feldman (1996), the primary goal of Action Research is not to generate new knowledge, but rather to improve and change classroom practices and learning environment. 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 (Kemmis & Mctaggart, 1988; O'Hanlon, 1996; Zuber–Skerritt, 1996). Each cycle of Action Research is repeated and all cycles form a spiral. Lewis and Munn (1987) indicated three main reasons for conducting teacher-based research: (1) to try to determine what is actually going on, (2) to monitor and thereby formatively influence the direction of new developments, and (3) to evaluate what is already happening in classroom.

Here, we describe a year-long professional development program aimed at enhancing the professional skills of teachers using the Action Research methodology. Ten chemistry teachers participated in the program that was led by two staff members (coordinators), and its objectives were:

- To provide support to the teachers who conduct *Action Research.*
- To encourage the creation of a professional community of chemistry teachers, and a leading-teachers team at school.

The ten participating teachers taught in high school and were experienced chemistry teachers. They met for a four-hour meeting each month, for a period of 30 weeks. The workshop

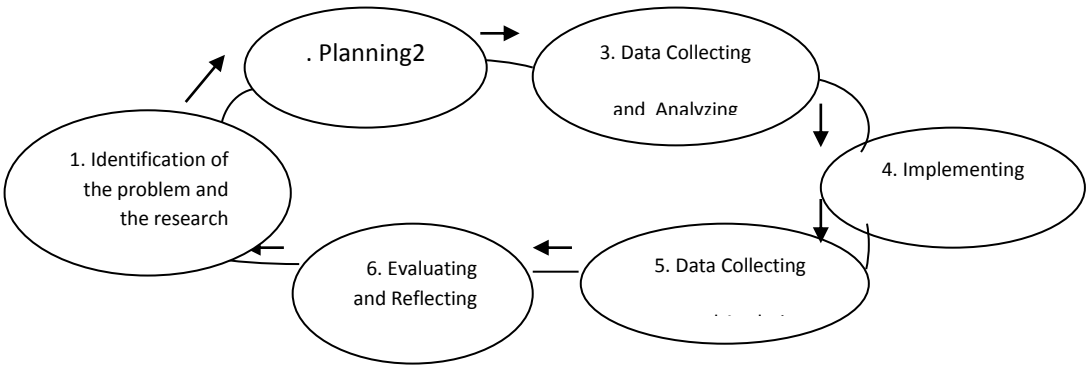

Figure 1: The Various stages of Action Research

coordinators discussed with the participants the various stages of their classroom-based Action Research: (1) identifying a general problem and the research question, (2) planning the research, (3) data collecting and analysing, (4) implementing, (5) data collecting and analysing, and (6) evaluating and reflecting (see Figure1).

Following is one example of a study conducted by two of the workshop participants, who were dissatisfied with their students' understanding of electrical conductivity concept. The literature deals with misconceptions about electrical conductivity and electrochemistry. Garnett & Treagust (1992) used semi-structured interviews to investigate students' understanding of electrochemistry. Ozkaya (2002) referred to a previous study of prospective teachers, which found that students from different countries and possessing different levels of knowledge hold common misconceptions about electrochemistry.

The two teachers discussed the subject in the workshop, and together with the other participating teachers they formulated their research question, and decided to change their teaching strategies by using models, videos and slides, educational computer programs, and computer animations. Their research question was:

> *"What are the misconceptions of students who study the electrical conductivity, and how can we improve their understanding"?*

During the workshop meetings, the teachers reflected upon their work, and received feedback from their colleagues.

Research tools

The two teachers developed the research tools with the support of the workshop participants:

1. Interviews

The interviews (before and after the teaching process) were semi-structured and consisted of cognitive questions aimed at determining what the students understood, using a model of an electrical circle.

2. An achievement test

The effect of the new strategies on students' knowledge was also evaluated using a paper and pencil achievement test.

Results

An analysis of the first interviews revealed typical misconceptions, such as:

1. The understanding of the accumulation of atoms.
2. The integration of the macroscopic and microscopic worlds.
3. The fact that the flow carriers in the ionic solution are electrons.
4. The fact that each compound that consists of a metal can conduct electricity.

Based on the achievement test results and the analysis of the repeated interviews the teachers reported that (1) Most of the students were able to distinguish between the electrical conductivity of metals and the electrical conductivity of ionic solutions and between the characteristics of copper as a metal and copper chloride as an ionic solution, (2) The students knew how to explain the relationship between the macroscopic and microscopic world, and (3) More students used models and were able to explain conductivity in terms of the microscopic world and the particulate nature of matter.

Conclusions and implications

The results of our study showed that the two teachers 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 workshop enabled them to realize that a reflective study has its own value and is indeed beneficial to their work. It strengthened their teamwork at school and encouraged the collaboration between themselves and their colleagues.

References

- Feldman, A. (1996). Enhancing the practice of physics teachers: Mechanisms for generation and sharing knowledge and understanding in collaborative Action Research. *Journal of Research in Science Teaching*, 33, 513-540.
- Feldman, A. & Minstrel, J. (2000). Action Research as a research methodology for study of teaching and learning science. In A. E. Kelly & R. A. Lesh (Eds.), *Handbook of Research Design in Mathematics and Science Education,* (pp. 429-455).
- Garnett, P.J. & Treagust, D.F. (1992). Conceptual difficulties experienced by senior high school students of electrochemistry: Electrochemical (Galvanic) and Electrolytic Cells. *Journal of Research in Science Teaching*, 29(2), 1079-1099.
- Kemmis, S. & Mctaggart, R. (1988). *The Action Research Planner*. (Eds.) Geelong, Victoria, BC, Canada, Deakin University Press.
- Lewis, I. & Munn, P. (1987). So you want to do research! A guide for teachers on how to formulate research questions. Edinburgh: Scottish Council for Research in Education.
- O'Hanlon, C. (1996). *Professional Development through Action Research in Educational Settings'*. (Ed.), Falmer, Washington, DC.
- Ozkaya, A.R. (2002). Conceptual difficulties experienced by prospective teachers in electrochemistry: Half-cell potential, cell potential, and chemical and electrochemical equilibrium in galvantic Cells. *Journal of Chemical Education*, 79(6), 735-738.
- Zuber-Skerritt, O.(1996). *New Directions in Action Research*. London, Falmer.

Appendix 4: The use of teachers' portfolio

What is a portfolio in the context of education?

Some theoretical background

Educational research that supports the potential of portfolio as evidence for teachers' professional development was widely reviewed and documented (see for example in a special issue of the *International Journal of Science Education* Vol 30 (5), 2008: e.g. Harrison, Hofstein, Eylon, & Simon. (2008)). Based on the literature the portfolio used in the context of CPD programs usually involves the selection of materials that provide evidence for critical examination of teaching and learning practices. Portfolios could be used for the purpose of: Judging the quality of a certain performance (for example to serve professional development providers), for making educational decisions-summative purposes, and in the context of CPD projects a more formative approach is taken for the purpose of observing change and development resulting from the CPD initiatives.

As mentioned above, accomplished teaching should always occur simultaneously with reflection, in order to improve the teaching strategy. It should be followed by protocols assembled in a portfolio, which can be used to demonstrate evidence-based accomplished practice in science teaching, in an effort to achieve more effective teaching. The portfolio should document the activities, interactions, and behavior in the chemistry laboratory where inquiry-type experiments are implemented. It can be viewed as a systematic and organized collection of evidence used to monitor the growth of a learner's knowledge, skills, and attitudes in a specific content area.

A teacher's portfolio is a collection of work produced by a teacher that provides evidence for teacher's practice in his/her classroom. It consists of a collection of materials to highlight and illustrates the teacher's knowledge, skills, and values. In the context of the PROFILES' project it provides evidence for the teachers' professional development, their practice in the classroom and ability to implement the PROFILES philosophy. In addition a well-designed teacher's portfolio can provide evidence for development of self-efficacy, ownership related to the project, and the development (in some cases) characteristics of leadership. The portfolio may consist copies of lesson plans, hand-outs, examinations, posters, video clips, examples of

students' work that represent the teaching philosophy of PROFILES, the teachers written reflection essays (self-reflection), and teachers beliefs.

The portfolio can be in written form or assembled electronically (e-portfolio).

For example, the teachers should be asked to write after each lesson, a summary consisting of:

- The context in which the activity was conducted
- The rationale for selecting particular activities
- The goals in mind regarding content and skills
- Instructions given to students
- Observations
- The teacher's reflection

Suggested additional reading:

Harrison, C., Hofstein, A., Eylon, B., & Simon, S. (2008). Evidence-based professional development of science teachers in two countries. *International Journal of Science Education*, 30(5), 577-591.

Taitelbaum, D., Mamlok-Naaman, R., Carmeli, M., & Hofstein, A. (2008). Evidence-based Continuous Professional Development (CPD) in the Inquiry Chemistry Laboratory (ICL). *International Journal of Science Education*, *30*(5), 593 – 617.