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ABSTRACT

This case study focuses on one approach to the professional development of science and technology with regard to Project-Based Learning (PBL). Sections include: (1) rationale and goals; (2) context, population, and methods of study; (3) content and sequence of the PBL workshop; (4) teacher projects; and (5) phenomena of note. Among the conclusions are that teachers are quite enthusiastic about PBL, and they expressed their desire to see it implemented in their classrooms. (Contains 10 references.) (MM)

Project-Based Learning (PBL) in Science and Technology: A Case Study of Professional Development

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Project-Based Learning (PBL) is "a teaching and learning model that focuses on the central concepts and principals of a discipline, involves students in problem-solving and other meaningful tasks, allows students to work autonomously to construct their own learning, and culminates in realistic, student-generated products" (Thomas, et al., 1999).

Despite the educational potential of PBL, it is clear that without providing proper attention to teacher development and school change, actualizing this potential will remain a dream (e.g., Marx, et al., 1997).

Our case study focuses on one approach to the professional development of science and technology in regard to PBL. First, we present the rationale and goals of our approach. Next, we describe the context, population and methods of our case study.

We present the sequence of the PBL Teacher Workshop, the resulting teacher projects in science and technology, and phenomena of note in the workshop. Finally, we discuss our findings and their relevance for practice in the professional development of science and technology teachers.

1. RATIONALE AND GOALS

"Project-Based Learning (PBL) in Science and Technology" is a constructivist method of teaching and learning that has been developed at the Department of Science Teaching at the Weizmann Institute of Science. Based on prior research about how teachers change (Rosenfeld, et al, 1997), our 3-stage approach focuses on supporting teachers as (1) learners of PBL, (2) practitioners of PBL in their classrooms, and (3) innovators of PBL in their schools.

The present study focuses on the first part of this 3-stage process. We present a case study of teachers as they are supported as "learners of PBL" in a special PBL Workshop. Our guiding goals are:

(a) to describe and document what happened during the workshop, and

(b) to analyze the potential of this approach for science education.

2. CONTEXT, POPULATION AND METHODS OF THE STUDY

For the past 7 years, a national reform effort has been undertaken to improve science and technology education in Israel. Part of this effort has involved the design and implementation of long-term teacher inservices (3 years, 540 hours) for teachers in middle schools.

One such long-term teacher inservice was organized at the Netanya Teachers Center between the 1997-2000 school years for 26 teachers of science and technology from the Arab sector. The inservice was held in the village of Tira for teachers from Tira and the surrounding villages.

As part of this inservice, a 10-lesson (30-hour) workshop on "project-based learning in science and technology" was given throughout the 1999-2000 school year. The authors of this article were the instructors of this workshop.

We used a variety of methods to document the workshop, the resulting teacher projects, and the reactions of teachers: observations, interviews, teacher feedback forms, and an analysis of the teachers' portfolios and final projects.

3. CONTENT AND SEQUENCE OF THE PBL WORKSHOP

In order to combine the learning of PBL skills with the learning of specific content, the teachers were first taught the central concepts and principles of a learning unit on the subject of the water cycle on Earth (Asaraf-Ben-Tzvi and Orion, 1999). The teachers were also taught skills related to "scientific communication" (Scherz and Spector-Levi, 1999). We then conducted our PBL workshop. During this workshop, teachers were asked to define, design and implement science and technology projects of their choosing, on the subject of water.

The PBL Workshop was based on having the teachers undergo a series of guided activities. In each activity, teachers were asked to produce "mini-products" (e.g., a list of questions, a leading question, appropriate references, a reseach design, a proposal, etc.) which progressively contributed to the production of the final project.

a. Asking Questions. (We designed an exhibitition of experiments, articles, equipment and challenges to elicit teacher questions relating to water.)
b. Choosing a Leading Question.
c. Locating and Reading Relevant Background Material.
d. Defining a Research Question or Design Problem.
e. Designing an Appropriate Methodology.
f. Writing a Project Proposal. (Teacher proposals were evaluated by peer-review as well by the instructors.)
g. Implementing and Documenting the Work.
h. Analyzing the Data and Drawing Conclusions.

i. Writing the Final Report.

j. Presenting the Projects.

During each stage, the instructors presented relevant activities, based on a PBL guide written for students (Breiner, Rosenfeld and Fallik, 1999). The teachers recorded and documented their work in loose-leaf portfolios.

4. THE TEACHER'S PROJECTS

As can be seen from the following table, the projects were varied, both in terms of topics and methodologies used. It should be appreciated that each project has its own 7-month history.

Project Topics	**Methodologies Used**
The Design of a Home Device for Softening Water for Washing Machines.	Invention, model-building, experiments.
A Comparison of the Working Mechanisms of Different Devices to Purify Drinking Water.	Model-building, survey.
A Study of the Most Popular and Most Effective Computerized Irrigation Systems.	Survey.
The Mediteranean Sea-Dead Sea Canal: Historical, Economic, Social and Environmental Aspects.	Academic literature review and model-building
Water Purification Systems for Home Use.	Survey.
The Effect of Different Concentrations of Saltwater on the Growth of Plants.	Experiment.
Examining the Effectiveness of a Home Water Purification Device.	Experiment.
A Study of Computerized Irrigation Systems.	Model-building and survey.

5. PHENOMENA OF NOTE

As a result of our observations and interviews, we noted a number of interesting phenomena:

a. *Team Formation.* The formation of project teams was not without conflict. At times, we needed to help these groups resolve their differences. However, each team eventually improved its cooperative work, resulting in a clear division of labor among the team members.

b. *Affective Aspects.* As predicted in past research (Rosenfeld et al., 1997) the teachers progressed from initial excitement to confusion and frustration, followed by fulfillment A month before the end of the workshop, the teachers said wanted to cancel the conference. Our reaction was that the conference would take place and that we would give them extra help. The conference did take place, the oral and written presentations were superb, and the teachers ended the workshop with a tremendous feeling of accomplishment.

c. *Skills-Based Difficulties.* Despite the positive outcome of the workshop and the generation of successful projects in science and technology, the teachers experienced a series of skills-based difficulties in the process, including asking focused research questions, matching these questions with the appropriate experimental methods, conducting the statistical analysis, and making conclusions based on the available data.

d. *The Integration of Science and Technology.* Most teacher projects integrated aspects of science with aspects of technology. Technological issues (e.g., those relating to water purification and computerized irrigation systems) were the springboard for the teachers to deepen their knowledge about basic scientific concepts and principles.

e. *The Promise of School Change.* Throughout the workshop, the teachers expressed interest in bring PBL into their classrooms and schools. Project-Based Learning is a novel educational pedagogy in the Arab sector in Israel. As a consequence of their "hands-on" exposure to this approach, the teachers were generally enthusiastic about PBL and filled with enthusiasm regarding its future promise. As one teacher noted::

"I hope that this way of learning (PBL) takes place in most of the schools in the Arab sector, because it's a way for teaching students to think like scientists and to turn into citizens who are aware of what takes place around them in the age of the computer and the Internet, and not to become citizens who are like passive 'tape recorders' that just receive information."

6. DISCUSSION AND CONCLUSION

The case study presented above highlights a number of important issues. First, it highlights the educational potential of the PBL approach. The teachers were quite enthusiastic about PBL and expressed their desire to see it implemented in their classrooms. Second, it highlights the difficulties experienced by the teachers during their PBL workshop (e.g., team-formation, affective aspects, skills-based difficulties).

Research has shown that classroom students experience these difficulties during the PBL process (Thomas, et al., 1999; Marx, et al., 1997). Third, it emphasizes the importance of providing a support system for teachers who want to learn and implement the PBL process in their classrooms.

These three issues -- the educational potential, difficulties and support system related to implementing PBL in science and technology -- reinforces the rationale behind our teacher development program. As mentioned at the beginning of this paper, our rationale is based on the recognition that teachers need support at three consecutive (and sometimes overlapping) stages in their development: as learners of PBL, as teachers of PBL in their classrooms, and as educational innovators (and agents of change) in their schools.

As learners of PBL, the teachers progressed from one stage to the next, experiencing various challenges along the way. These challenges (team-formation, affective aspects, skills-based difficulties, as described above) are typical to all PBL work (Thomas, et al., 1999; Marx, et al., 1997). By experiencing and dealing with these difficulties "in first person," our assumption is that they will be better able to help their students do the same when they engage in PBL.

As teachers of PBL in their classrooms, many different difficulties await our teachers.

For example, in an study of 12 expert PBL teachers, 7 major problem areas for PBL implementation were identified: (1) time management, (2) getting started, (3) establishing a culture that stresses student self-management, (4) managing student groups, (5) working with others outside the classroom, (6) getting the most out of technological resources and (7) assessing students and evaluating projects (Mergendoller and Thomas, 2001). We would add two other problem areas: teaching

PBL skills and balancing the teaching of PBL skills with the learning of subject-domain specific content. Of course, management principles for the practicing PBL teacher exist; the study of expert PBL teachers identified 53 such "classroom management principles." However, the systematic learning of these principles by practicing PBL teachers is not a simple matter.

As educational innovators, our teachers will be called upon to access and/or develop knowledge from such areas as organizational development and school change.

Well-respected and recognized experts in these fields talk about the immense difficulty of sustaining innovations within educational institutions. In the words of one such expert, the "traditional fate of innovations (include) dilution, withering, distortion, trivilization, (and) reversion to traditional practice" (Huberman, 1997). So the challenges to be faced in this area are not simple either.

Given these challenges, how might the professional development of teachers in PBL be promoted? Our anwswer to this questions is that a long-term system of support is needed to help teachers effectively learn and implement PBL.

One such long-term support system is described as the "interlocking loops" model of professional development (Rosenfeld, et al., 1999). Four target audiences are linked by three interlocking loops of support: (1) teacher teams support students (in their PBL work), (2) leading teachers support teacher teams (via in-service workshops and school guidance), and (3) teacher educators support leading teachers (via seminars and in-service guidance). In practice, the four audiences may be more flexible in their interactions than shown. Also, other audiences (e.g., principals, parents, community-based experts, etc.) may participate in the three support loops. (See Fig. 1 and Table 1.)

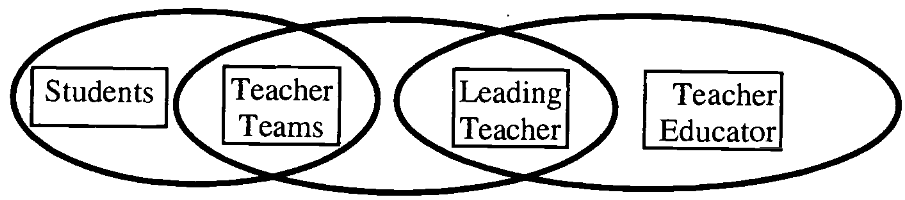

Figure 1. Interlocking Model of Professional Development in PBL

Despite the difficulties teachers experience in learning, implementing and institutionalizing PBL, the PBL approach has generating a great deal of teacher

and student enthusiasm. The combination of student-generated questions with standards-based principles and concepts withinin a context research skills development is an appealing mix for teachers as well as students.

We conclude that "Project-Based Learning in Science and Technology" can be a significant catalyst for helping teachers to introduct "a new spirit" into science and technology education: focusing on learner-centered approaches to learning, integrating science and technology, providing an authentic project work, participating in cooperative staff work and learning how to learn.

This case study represents only the beginning of the 3-stage model for professional development we have adopted for our teachers ("the teacher as learner of PBL"). This school year we are supporting these teachers in the second stage (as "practitioners of PBL" with their students). The third stage of our model ("teachers as PBL innovators in their schools") is planned for the following school year.

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