Involving Science Teachers in the Development and Implementation of Assessment Tools for "Science for All" Type Curricula

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Introduction

The release of the *National Science Education Standards* (National Research Council, 1996) served as a landmark in identifying a comprehensive set of goals for achieving scientific literacy for all American students. The National Science Education Standards (NSES) define in broad terms the scientific concepts and processes that all students should know and be able to apply. Most importantly, they provide guidelines for assessing the degree to which students have mastered the content of the standards. In addition, the standards detail the teaching strategies and support necessary to deliver high-quality science education to all students. A reform providing education in the sciences for all the students has been in progress in Israel during the last twelve years (Tomorrow 98: Report of the superior committee on science mathematics and technology in Israel, 1992).

In this paper we will describe a workshop in which teachers participated in the development of alternative assessment methods in the context of implementing a new science curriculum for senior high-school students, namely “Science for All” (Dori & Hofstein, 2000), using the Science-Technology-Society (STS) approach. We also suggest a model for a professional development program for teachers who implement a new curriculum, and evaluate its impact on the attitudes of teachers and students towards implementing this curriculum.

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The new STS curriculum consists of a series of interdisciplinary modules, each tackling a specific problem in the interface between science, society, and technology. Each of the modules presents a certain scientific topic with its technological, social, and personal applications and ramifications (Cohen, Ben-Zvi, Hofstein, & Rahamimoff, 2004). The STS approach emphasizes the application and relevance of science to everyday life, and thus, it is expected to increase students' motivation to learn science (Byrne and Johnston, 1988). However, applying these dimensions to science education requires an alteration in the way we teach science, namely the utilization of new instructional strategies. Hofstein and Walberg (1995) and Tobin, Capie, and Bettencourt (1988) claimed that instructional techniques in science should be matched with the students' characteristics and needs, as well as with appropriate assessment tools, in order to maximize the effectiveness of the teaching and learning processes as well as to increase students' motivation.

Based on our previous experience and on studies referring to the implementation of new interdisciplinary programs (Fensham, 1992), the following are challenges that teachers who participated in the STS workshop faced:

1. A new subject matter in which they were not originally prepared. Some of the teachers had experience in teaching only specific science subjects, e.g., chemistry, biology or physics), and were not be familiar with interdisciplinary topics.
2. A lack of familiarity with the instructional strategies necessary for diversifying classroom procedures, including discussions, debates, and personal actions as a result of a daily encounter with scientifically based phenomena, and role-playing. The teachers may not have been exposed to the diversity of teaching strategies that are required for implementing this interdisciplinary approach (Hofstein, Aikenhead, & Riquarts, 1988).
3. The lack of valid and reliable STS assessment tools that enable students to demonstrate their actual classroom learning; this inhibits the assessment of this

unique learning and teaching process. In addition, the assessment of student learning is a difficult and very demanding task because of the diverse nature of STS instruction and learning.

In order to assist a group of teachers (who began teaching the STS program) in both teaching and assessment methods, and to design a model for a professional development program for teachers who implement a new curriculum, it was decided that the Department of Science Teaching at the Weizmann Institute of Science would sponsor a workshop for them. More specifically, the workshop was initiated to address the teachers' questions: *"What strategies should we use in teaching STS-type modules, and how should we assess the students who are studying such modules?"*

The objectives of this workshop were as follows:

- To increase teachers' interest in a new science curriculum;
- To improve science teachers' ability to develop and use appropriate assessment tools for the new interdisciplinary curricula;
- To determine whether the diversity of teaching methods and their aligned assessment tools matched the learning goals and were suitable for the new interdisciplinary program and beneficial for the students;
- To determine whether the assessment of students by alternative methods had an impact on students' learning habits.

An evaluation study was conducted during the workshop and at its completion. The main goal of the study was to evaluate the outcomes of the workshop and to determine whether its objectives were attained.

Theoretical Background

"Science for All" emerged as a slogan that embodied a new challenge for science educators, both at the developmental level as well as in the implementation stages of the curriculum (Bowyer, 1990; Fensham, 1992; Yager, 1993; Bybee & Ben-Zvi, 1998; Hofstein & Mamlok, 2001; Mamlok, Ben-Zvi, Menis, & Penick, 2000). Harms and Yager (1981) stated that Science for All should be part of the education of those who will eventually be "future citizens." In their report *Project Synthesis*, they considered four interrelated "goal clusters" for teaching science: (1) science for personal needs, (2) societal issues, (3) career awareness, and (4) academic preparation. These multiple approaches served to develop science teaching in its authentic context (Yager, 1996). The STS approach attempts to present science, together with its technological and social manifestations. Yager (1996) claimed that this approach has great potential to enhance the attainment of the above-mentioned goals. Thus, it will help in shaping the character of science-literate citizens (Hofstein, Aikenhead, & Riquarts, 1988). Consequently, it is suggested that individuals in society will be able to make important decisions about current problems and issues of a scientific origin, and personally act as a result of these decisions. In addition, as a consequence, citizens who understand how science, technology, and society mutually interact will be able to use their knowledge in handling the problems and issues that they confront (Bybee, 1997). These multiple approaches of the social, economic, and environmental aspects of science are often absent in curricula that are exclusively based only on the acquisition of scientific knowledge. By learning through the STS instructional approach students are taught about natural phenomena in a way that links science with the technological and the social world of the student (Hofstein, Aikenhead, & Riquarts, 1988; Bodzin & Mamlok, 2000; Hofstein & Mamlok, 2001).

In order to effectively implement STS-type curriculum materials, mainly in the upper secondary level of schooling, we must consider the preparation and the professional development of the science teachers. The interdisciplinary nature of the subject matter included in the STS-type program is demanding (Penick, 1984). Studies have also examined the way in which teachers' beliefs influence the STS implementation process (Tobin, Tippins, & Gallard, 1994). Teachers' beliefs throughout a professional development program can influence the success of a reform initiative (Fetters, Czerniak, Fish, & Shawberry, 2002). In fact, teachers are "agents of change" regarding educational reform, and their beliefs must not be ignored (Bybee, 1993). Moreover, their beliefs are at the "core of educational change" (Haney, Lumpe, Czerniak, & Egan, 2002). In investigating the STS curriculum, Mitchener and Anderson (1987) studied 14 teachers and 200 students. The data collected were analyzed according to three categories: acceptance, rejection, or alteration of the STS curriculum. They found that teachers who felt that the STS curriculum enhanced their students' motivation to better cope with real-life situations and decision-making were more positive regarding the teaching of STS-type curricula. However, those who disliked the inclusion of social-studies content and the lack of science topics rejected the STS curriculum. More recently, Sweeney (2001) conducted a study in which STS-type issues were incorporated into science teacher education courses. In his study he discovered that prospective elementary and secondary teachers often resist the incorporation of STS issues as a legitimate component of courses focusing on science teaching methods.

The implementation of a wide spectrum of instructional techniques in the science classroom necessitates matching an appropriate assessment tool for each learning goal to measure the students' achievements and progress (Trowbridge & Bybee, 1996; Hofstein, Mamlok, & Carmeli, 1997).

According to the National Research Council (1996):

> *"Assessment policies and practices should be aligned with the goals, student expectations, and curriculum frameworks. Within the science program, the alignment of assessment with curriculum and teaching is one of the most critical pieces of science education reform".* (p. 211)

The need to match assessment tools to the learning goals has received support in studies conducted in chemistry by Ben-Zvi, Hofstein, Samuel, and Kempa (1977), and in biology by Tamir (1974). Their work clearly shows that achievement in written exams is not highly correlated with achievements requiring inquiry abilities, which are manifested by laboratory work. Moreover, Shavelson, Baxter, and Pine (1990) compared multiple-choice tests with hands-on performance assessment and found that the correlation between these variables is only moderate.

Different ideologies and different research agenda led to the development of some research tools that try to assess students' learning regarding the STS programs. Enger and Yager (2001) offer several methods for assessing science standards, with grade-level examples, rubrics, teacher assessments, and examples of student work. The Views on Science-Technology-Society (VOSTS) instrument (Aikenhead & Ryan, 1992), for example, measures students' understanding of the nature of science, and students' understanding and attitudes toward STS topics. VOSTS is derived directly from students' own views on various issues of STS. It consists of a pool of 114 multiple-choice items surveying a wide variety of STS topics, different from traditional instruments that are derived from researchers' conceptual schemes (Aikenhead, Ryan, & Desautels, 1989). Another tool, developed by Zuzovsky (1997), measures the ability to apply scientific principles in non-academic contexts. One of the tasks describes a family's use of an electrical appliance. The students were asked to calculate the cost of electricity used through the provided data, decide upon several daily issues such as the heating methods, compare several types of power stations, and identify commonalities and differences, and finally, to critically analyze a newspaper advertisement regarding environmentally friendly actions undertaken by the electricity company.

In the framework of reform in science education an extensive, dynamic, and long-term professional development of the science teachers should take place (Loucks-Horsley & Matsumoto, 1999; National Research Council, 1996). Teachers need to receive guidance and support throughout the various teaching and implementation stages involving changes in the curriculum (Harrison & Globman, 1988; Loucks-Horsley & Matsumoto, 1999). On the one hand, it is not easy for the teachers to undergo modifications that include changes in the content and in the way they teach. On the other hand, it has been noted that teachers, in general, are excellent learners, and are interested in trying to teach a new curriculum, as well as in improving and enriching their teaching methods (Joyce & Showers, 1983). An integrated science curriculum differs from a traditional science curriculum. Science teachers usually receive good preparation in teaching the traditional science curriculum - one or two science disciplines, but not integrated science. However, they need to learn the knowledge, skills, attitudes, and teaching skills to teach such an interdisciplinary topic (Bybee & Loucks-Horsley, 2000). They should be encouraged to expand their repertoire of student assessment strategies to include such techniques as observation checklists, portfolios, and rubrics (Wiggins, 1988).

One of the ways of overcoming the anxiety of teachers regarding reforms such as STS, requires their active involvement in the development of learning materials, instructional techniques, and related assessment tools (Loucks-Horsley, Hewson, Love, & Stiles, 1998; Parke & Coble, 1997). Similarly, Sabar and Shafriri (1982) claimed that

> *"Participation in curriculum development, which is a protracted process, is likely to take the teacher from a conscious phase to one of greater autonomy and internalization phase".* (p. 310)

It is generally believed that involving teachers in the process of curriculum development leads to a wide variety of pedagogical ideas regarding instructional techniques and their related tools (Connelly & Ben-Peretz, 1980). Based on this rationale, we designed a workshop for science teachers to implement learning materials and to develop assessment tools for a "Science for All" program.

The STS Program

The 'Science for All' program was developed as part of a more comprehensive reform in science education that has been evolving in Israel since 1992. In the early 90s the Ministry of Education in Israel set up a committee that considered the need to make science an integral part of the education of all citizens (Tomorrow 98: Superior Committee on Science, Mathematics and Technology Education in Israel, 1992). In 1992 the recommendations of the committee were accepted and the government committed itself to the decision that science will be taught to all high-school students in the country. It was also decided that different programs will be taught to science and non-science-oriented students, namely high-school students (grades 10-12), who did not choose to major in any of the science disciplines (biology, chemistry, or physics), the reasons for which are numerous and diverse. We assume that some of these students have a poor attitude toward science, which declines from junior to senior high school (Neathery, 1997; Weiss, 1987).

The 'Science for All' program consists of a set of 15 modules (35-40 hours each), all having an STS-type structure and content. Each module focuses on a specific scientific topic (Dori & Hofstein, 2000). Some modules that already have been developed and implemented include the following: *Energy and the Human Being* (Ben-Zvi, 1998; Ben-Zvi, 1999); *Science: An Ever-Developing Entity* (Mamlok, 1998), and *Brain, Medicine, and Drugs* (Cohen, 2000; Cohen, Ben-Zvi, Hofstein, & Rahamimoff, 2004). *Energy and the Human Being* tries to clarify some issues concerning many beliefs and misconceptions about energy (for more details, see Ben-Zvi, 1999). *Science: An Ever-Developing Entity* was designed to develop an understanding of the nature of science by using historical examples. In this way, science is presented as a continuously developing enterprise of the human mind in the context of the historical development of our understanding of science (Erduran, 2001; Mamlok, Ben-Zvi, Menis, & Penick, 2000). *Brain, Medicine, and Drugs* focuses on several selected aspects of brain research and its relationship to human behavior and emotions.

When teaching the modules, the teachers are expected to use a wide range of pedagogical interventions and instructional techniques in order to cope with a wide range of student abilities, interests, and means of motivation. Moreover, the implementation of such an STS program with a wide spectrum of learning goals necessitates matching to each learning goal its instructional technique as well as an assessment tool to measure students' achievement and progress (Hofstein, Mamlok, & Rosenberg, in press).

Methods

The STS Workshop

We describe a workshop that was accompanied by evaluation procedures, in order to determine whether the objectives of the STS were accomplished. The workshop participants met eight times, four hours every second week (Novenber 2001-February 2002). Two science education researchers conducted the STS workshop and the research associated with it. They were experts in curriculum development and in the professional development of teachers.

The workshop was initiated to address the teachers' questions: *"What strategies should we use in teaching STS-type modules, and how should we assess the students who are studying such modules?"*

Workshop participants

The workshop participants consisted of 10 science teachers from ten different high schools in Israel. Each taught the "Science for All" program in one class 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. Their scientific backgrounds differed, and included areas such as chemistry, biology, agriculture, nutrition, technology, and physics. The teachers had already taught the "Science for All" modules previously mentioned but had difficulties in using a variety of teaching strategies in general, and in grading and assessing their students in particular. Each of the teachers who participated in the workshop had taught at least one of the “Science for All” modules in one class consisting of about 30 students.

Characteristics of the Workshop

As mentioned above, the workshop was initiated in order to address the needs of the teachers who implemented the 'Science and Technology' program, regarding their teaching strategies and the related assessment methods. Therefore, the workshop coordinators focused on guiding the participating teachers in using a variety of teaching strategies, and in the development of auxiliary assignments for their students, together with assessment tools. The assessment tools used in this workshop consisted of detailed checklists (rubrics) and rating scales (see Appendices 1 and 2). In the first three meetings, the participating teachers were exposed to lectures and to activities related to alternative assessment tools and methods, and especially to the way in which they should get used to working with rubrics.

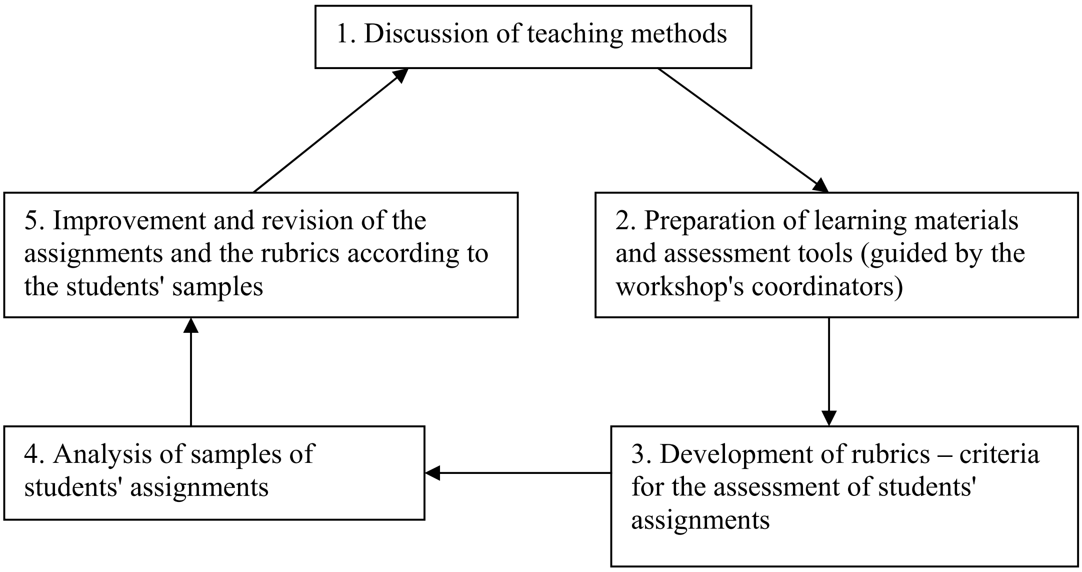
Each teacher prepared the assignments for his or her students, followed by assessment tools. The assessment tools included tests, quizzes, and assessment guides for carrying out mini-projects, writing essays and critical reading of scientific articles. All the assignments were developed in stages, each of which required consideration and an analysis of assessment criteria as well as scoring. These assignments were administered stage-by-stage at school.

The students were involved in the assessment methods and their respective weights. This continuous assessment provided them with more control over their achievements, since they were aware of the assessment method, the weight percentage for and the each of the assessment components, and the final grade. At each stage, the students submitted their papers to the teacher for comments, clarification, and assessment. The students met the teachers before and after school for extra instruction and consultation. The detailed checklist given to each student after each assignment compelled them to address the comments with the greatest seriousness if, of course, they wanted to improve their grade.

The students reflected on their work and ideas at each stage, and followed their teachers' comments on a detailed checklist and corrected them accordingly. Thus, they were able to improve their grades. The teachers revised the rubrics related to the assignments at each stage. Samples of the students' assignments were brought to the workshop for further analysis, involving both the coordinators and their colleagues – the participating teachers. The group discussed the revision of the rubrics, and agreed on the percentage (weight) allocated to each of the assignment's components. They also agreed on the criteria for levels of performance, in order to grade the students as objectively as possible (for more details, see Appendices 1 and 2). The different components of the workshop are presented in Figure 1, specifically (1) discussions of the teaching methods, (2) preparation of learning and auxiliary materials and assessment tools, (3) development of rubrics - criteria for the assessment of the assignments, (4) analysis of samples of students' assignments, and (5) improvement and revision of the rubrics according to samples of the students' assignments.

Figure 1

The different components of the workshop



At the end of the year, the students of each class presented their assignments to an audience consisting of their peers from parallel classes, their parents, science teachers, the school principal, and us.

Examples of Two Assignments

Each teacher developed various student assignments and assessment tools. Assessment criteria for the assignments were suggested and discussed in the workshop in terms of both their content and weight. The following two assignments will serve as examples. Their related assessment rubrics are presented in Appendices 1 and 2.

I. critical reading of scientific articles published in newspapers or other media and original scientific articles published in scientific newspapers

Scientific articles published in daily newspapers and in scientific newspapers can serve as an important source for enrichment and for making the subject studied more relevant and up-to-date (Wellington, 1991). Scientific articles published in scientific newspapers can be classified as primary literature. The articles are originally written by scientists, more specifically, these consist of scientists' reports on their research work, ultimately, being published in professional journals (Yarden, Brill, & Falk, 2001). In order to use them in high school, however, they should be modified into a popular, easily readable version. However, regarding daily as well as scientific newspapers, critical reading of articles is thought to contribute to developing a literate student in the sciences (Norris & Phillips, 2003).

Each student in class had to choose an article from a collection of diverse articles provided by the teachers. The students were also provided with a written guide for critically reading the paper (Levy Nahum, Hofstein, Mamlok-Naaman, & Bar-Dov, 2004). The articles given to the students dealt with the following topics: *Important elements, The Discovery of the Rare Earth Elements, Chemistry in the Bible, Thermodynamics and Spontaneity, The Story of Energy, Chemical Aspects of Atmospheric Pollution,* or *The Special properties of the NO compound.* For example, the following is a short description of the content of an original scientific article:

> *Nitric oxide (NO)* acts as a single molecule in the nervous system, as a defense agent against infections, as a regulator of blood pressure, and as a 'gate keeper' of blood flow to different organs. In the human body it is thought to have a lifetime of a few seconds. Thus, its direct detection in a low concentration is rather difficult.*

The article reports on the design of a new electronic sensor sensitive to small amounts of NO in physiological solutions and at room temperature. The following are the stages of the detection process: NO binds to the surface area of the detection device (composed of an organic compound). The organic compound is attached to an alloy of GaAs (Gallium Arsenic), a semiconductor. As a result of the change in the surface, due to the binding of NO, the current flow in the alloy changes and is sensed by a detector. (Based on: Wu, Cahen, Graf, Naaman, Nitzan & Shwartz, 2001).

The article underwent a simplification stage in order to adopt it to the students' reading ability and to their chemistry background. For the purpose of simplification, the article was organized (and written) in sections, namely abstract, introduction, research methods, results, and summary. The introduction presented the needed scientific background. In addition, in the introduction, we also provided the students with a glossary of new and unfamiliar words, equipment, etc., such as semiconductors, and resistors. The research method introduces the students to methods that the scientists used in their work. At the end of the article we wrote a short summary containing the main ideas incorporated in the article. The results were presented on a graph that shows the different experimental conditions. The article was selected since we assumed that it presents a topic that could be characterized in terms of "frontiers of chemistry", as relevant, and as one that had a technological application. Thus, we thought that it would be of interest to the students.

The students were asked to read the article and then to

1. Identify at least five scientific concepts whose meaning is unknown to them.
2. Compile questions that raise criticism of the article's contents.
3. Answer the compiled questions.

II. Writing an essay focusing on scientists and their discoveries, entitled "The Person behind the Scientific Endeavor"

In order to help students in writing an essay about *"The Person behind the Scientific Endeavor"*, the teachers introduced them to the biographies of numerous eminent scientists from different periods. These scientists developed scientific theories that often contradicted those that had been previously accepted (Mamlok, 1998). The students were asked to describe in detail the lives of these scientists and the discoveries made by them. They also produced work characterizing "their" scientists: a picture of the scientist accompanying an article that the students had written. The students used internet resources, and the teachers helped them with references dealing with the history of science (Conant & Nash, 1964; Priesner, 1991; Seybold, 1994; Rayner-Canham & Rayner-Canham, 1998). Afterwards, the class constructed a display along a time-line in order to place events, scientists, and theories in their appropriate historical perspective. Thus, all the students felt that each scientist represented by them had been given an honorable place in the history of science.

Data Collection and Analysis

The data that we were interested in referred to the main goal of the study, namely, finding out whether the objectives of the workshop were attained. We used self-report questionnaires and interviews of teachers. This decision was based on the literature (Lawrenz, 2001), claiming that such instruments could be regarded as valid and reliable if they were administered and the data were collected at times when a person's almost immediate response can be obtained.

Regarding the students, we focused on the affective aspects of learning and not on the cognitive ones, since one of the main objectives of the reform in Israel was to make science an integral part of the education of all citizens (Tomorrow 98: Report of the superior committee on science mathematics and technology in Israel, 1992). Changing the attitudes of non-science-oriented students toward science is one of the main objectives of the reform in Israel. Four sources of data were used: (1) an attitude questionnaire administered to participating teachers, (2) semi-structured interviews with the teachers, (3) minutes of the meetings, (4) an attitude questionnaire administered to the students, and (5) structured interviews with students. The analysis of the interviews and the minutes was done according to basic methods of qualitative data analysis (Glaser & Strauss, 1967; Tobin, 1995).

An attitude questionnaire administered to the participating teachers

A Likert-type attitude questionnaire was administered to the teachers after the workshop was completed. It was a 1–4 scale inventory (in which 4 stands for "Fully agree", and 1 for "Do not agree"). It consisted of seven items assessing the teachers' opinions regarding the extent to which the workshop contributed to their knowledge and to their ability to teach the program, the impact on their motivation to implement their newly acquired tools, and their desire to participate in a follow-up workshop dealing with the development of learning materials (see Appendix 3 for the various items).

Semi-structured interviews with the participating teachers

Semi-structured interviews (30 minutes each) with the ten teachers who participated in the workshop were conducted 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 interviewer was the first author of this paper.) In the interviews the teachers were asked about subjects similar to those appearing in the questionnaire. This was done in order to validate their responses to the questionnaire and to obtain more information. The interviews were audio-recorded, transcribed, and analyzed by the first author of this paper according to four main categories that emerged from the teachers' answers:

- Teachers' self-confidence in teaching a new curriculum
- Expertise in alternative assessment
- Expertise in specific teaching methods
- Interest in interdisciplinary issues

Minutes of the workshop meetings

The first author of this paper wrote a protocol of the discussions held during the meetings. From reading the minutes of the meetings, the researchers could learn about the teachers' conceptions regarding students' learning and their learning environment, their attitudes toward a variety of teaching and assessment strategies, as well as the teachers' specific difficulties. The minutes helped us clarify the data collected from the interviews and were analyzed according to issues that revealed during the meetings.

An attitude questionnaire administered to the students

In order to check the consistency of the students' responses to the interviewer's questions, each student had to complete a questionnaire right after the interview. The questions were similar to those of the structured interview. This questionnaire consisted of Likert-type items in which 4 stands for "Fully agree", and 1 for "Do not agree"; it had seven items aimed at probing the students' satisfaction with the process of learning and their interest in it (see Appendix 4 for various items).

Structured interviews with the students

The researchers visited the schools at the completion of the STS unit and interviewed a sample of students from the ten teachers who had participated in the workshop (a total of 40 students, about 13% of the students). In each class, the researchers interviewed four students who were chosen by their teachers according to their achievements (two high achievers and two low achievers). The interviews were short, and consisted of three questions:

- *How do you feel about this program?*
- *What is the difference between the way you were assessed in this program and by "paper and pencil tests"?*
- *Were your learning habits influenced by this ongoing assessment?*

The interviews were audio-recorded and the content was analyzed according to three themes:

- Satisfaction with the assessment methods
- Interest in the process of learning
- Satisfaction from the ongoing dialogue

Findings

The findings will be presented in two sections. In the first section, we will present findings regarding the teachers, whereas in the second one, we will focus on the students.

Findings related to teachers

Table 1 refers to the ***questionnaire***, and presents the teachers' attitudes regarding how the workshop contributed to their work. Based on Table 1, it is clear that most of the teachers expressed their satisfaction with the workshop, specifically regarding:

- Their ability to teach the program and understand students' difficulties.
- Their motivation to teach the new curriculum. It increased their interest in the STS program, made them feel proud to have had an impact on the program, and increased their motivation to develop learning materials for their students.

Table 1: *The teachers' attitudes regarding how the workshop contributed to their work (N=10)*

Statements related to the workshop	$\bar{x}$	SD
Knowledge		
It affected my ability to teach the program.	3.80	0.42
It helped me understand students' difficulties.	3.70	0.48
It improved my teaching strategies.	2.80	0.92
The assessment tools were beneficial for the students	3.70	0.48
Motivation		
It increased my interest in the program.	3.70	0.48

It made me feel proud to have had an impact on the program.	3.80	0.42
<u>Motivation regarding professional development</u>		
I would be happy to participate in a continuing education workshop for developing learning materials	3.60	0.52
I would recommend that my friends participate in a similar workshop.	3.90	0.32

The teachers gave high scores to most of the items. The mean value (3.5) can be considered as "Fully agree". However, out of the ten teachers who participated in the workshop, only seven agreed with the statement "It improved my teaching strategies" (two of them fully agreed). We assume that since the workshop participants were experienced and knowledgeable teachers, most of them had already acquired a diversity of teaching strategies. Moreover, the improvement of the teaching strategies was not one of the main goals of the workshop (although this topic was discussed among them). The workshop activities were focused more on improving the science teachers' ability to use appropriate assessment tools for the new interdisciplinary curricula, and on matching these tools to the learning goals and to the diversity of teaching strategies. However, in the interviews, some teachers did mention the contribution of the workshop to some specific teaching strategies.

Teacher interviews

The interviews with the teachers were analyzed according to four main categories that emerged from the teachers' answers. In each case we summarize a representative quote from one or two teachers, which illustrates the teachers' opinions. All the mentioned names are pseudonyms.

Self-confidence in teaching the new curriculum

Eight teachers emphasized that the workshop contributed to their ability to cope with the new interdisciplinary curriculum. Some of them claimed that the workshop helped them better understand the objectives of the program in terms of their own interests, difficulties, and prior knowledge of basic concepts. This can be exemplified by the words of Dana:

> *"If we struggle with the subject matter - trying to understand it and to explain it to others - then we understand the students' difficulties and the need to find strategies to teach the subject matter."*

Expertise in alternative assessment

All the participants mentioned that because of the workshop they better understood the meaning of alternative assessment and its advantages, despite its time-consuming procedure. For example, Eric said:

> "*I felt that I had gained an additional advantage after attending the workshop. During the workshop I gradually incorporated new teaching and assessment strategies into my regular classes."*

Most of the participants agreed that alternative assessment would become part of their teaching methods in all the issues and topics that they dealt with. They also noted that the continuous assessment of students' progress and achievements provided a valid and reliable picture regarding the students' knowledge and abilities. In fact, they adopted these methods in their regular classes as well. To illustrate, Shelly, one of the teachers stated:

“Now I adapt the teaching strategies to the assessment procedures or to the assignments given to my students."

Expertise in specific teaching strategies

Some teachers referred to specific skills that they had gained in the workshop, such as how to ask questions, how to prepare inquiry experiments, how to guide students in working on mini projects and to reflect on their work, and how to teach in small groups. Four of the participants claimed that it changed their perception of the teacher's role. For example, Sarah said:

“My perception of the teacher's role in class has changed. I learned how to encourage students to learn independently, how to work with them on their projects (individually or in small groups), and how to ask questions.”

She also mentioned the fact that acquiring assessment and evaluation skills from the teamwork stimulated her creativity and diversified her instructional strategies in the classroom.

Increasing interest in interdisciplinary issues

The science teachers who usually taught the traditional scientific disciplines (namely, chemistry, biology, agriculture, nutrition, technology, and physics), and who were not familiar with the interdisciplinary subject matter felt that *"The best way to cope with an unfamiliar interdisciplinary subject is to be involved in its development, and by working in a group and cooperating with colleagues."*

The results from the teachers' interviews reinforced their answers in the attitude questionnaire regarding their ability to teach the program, to improve their teaching strategies, and the motivation to teach such a new curriculum.

Minutes of the workshop meetings

Reading through the minutes of the workshop also confirmed the fact that the reports of the teachers in the workshop stimulated discussions and debates among the participants, created a deeper understanding of the material, and provided greater insights regarding the students' learning process.

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 a sense of ownership regarding the new curriculum because of their personal involvement in the development of the learning and assessment activities and tools.

Findings related to students

The analysis of the **interviews** with the students and the questionnaire administered to them after each interview revealed that the students, with no exceptions, responded positively to the new teaching strategies and these alternative assessment methods. Quotes from five representative students will illustrate the general attitudes. The quotes were chosen from the interviews with Nadav, Gila, Jonathan, Tami and David (pseudonyms). Nadav, Jonathan, and David were low achievers, whereas Gila and David were high achievers. The following themes were emphasized:

Satisfaction from the process of learning

The students' comments referred mainly to the ongoing dialogue with their teachers, to the variety of assignments and to the alternative assessment tools. The ongoing dialogue with the teachers was new to them, and they appreciated very much meeting with their teachers before and after school for extra instruction and consultation. They said that in the past they had never experienced such a serious attitude toward them on the part of the teachers. Many of them claimed: *"Are we so important to you? You're devoting so much time to us."*

Satisfaction with the assessment methods

Regarding the assessment methods, the students claimed that they were linked to the teaching methods and the various assignments they had completed. The variety of assignments enabled them to be at their best with certain assignments, and to succeed less with others. In each assignment the students were given an opportunity to correct their work after the teacher had commented on it. Some students also mentioned that they would have achieved a final grade higher than the one they had achieved if they had merely studied for the matriculation examination. Nadav, one of the low-achiever students said:

> *"At the beginning, I thought that perhaps it would be better to do the matriculation exam, but on the other hand, if I had been given a low grade on the*

exam, I wouldn't have been able to improve it. But with the assignments, if I got a low grade on one, I had others with which to raise my grade, and even with the first paper, I had a 'second chance' to improve it."

In addition, the students felt that the assessment used better reflected their abilities and better represented their learning efforts. One could hear statements such as:

Gila, a high-achiever student: *"The assessment system is great. It's a correct system; you work right through the year. You show your ability and the grade is a true one, not just for one matriculation exam. Over the year you can improve your work, correct it… The students' intensive work improved both their written and verbal expression, as well as their skill in searching for and retrieving sources of information."*

Jonathan, a low-achiever student: *"In your papers you can express yourself in many ways, not only in "dry" writing but also by presenting a paper on the computer or in a story like the one about Radioactivity. It's easier for me to express myself this way."*

Interest in the process of learning

The students said that studying this program changed their learning habits, from studying only before an examination to continuous study. The following are two examples of the comments of Tami and David (pseudonyms), both low achievers:

Tami: *"In the other matriculation exams that I took this year I crammed for two weeks beforehand, whereas here it was a case of intensive study throughout the year."*

David: *"Throughout all my years at school I wouldn't sit down and study, but in this* *subject I sat down and made an effort, read, and took an interest; it taught me to prepare my work; it opened up new horizons for me. I didn't do it as a punishment; I knew that my papers were my grade. And [a great deal] remained from my work; it wasn't like studying for an examination."*

Table 2 presents the means of students' responses to the various items in the **questionnaire.** Specifically, it reflects their satisfaction with the process of learning and their interest in it.

Table 2: *Students' satisfaction with the process of learning and their interest in it (N=40)*

Item	$\bar{x}$	SD
The learning activities were diverse	3.28	0.93
Learning was interesting	3.10	1.03
The assignments were varied	3.43	0.75
This learning method was satisfying	3.15	0.89
It was clear to me how I got my grades	3.35	0.74
I think that the grades I got in chemistry were fair	3.50	0.64
I had an ongoing dialogue with my teacher	3.22	0.88

The results summarized in Table 2 support the results obtained in the interviews. Accordingly, we may conclude that most of the students were satisfied with (1) the learning materials, (2) the learning strategies, and (3) the assessment methods.

Discussion and Conclusions

The workshop discussed in this paper was initiated in order to assist a group of teachers who asked for support in implementing a new science curriculum in both teaching and assessment strategies. It brought together teachers from different backgrounds (biology, chemistry, physics or agriculture), but with one common objective, thus enabling them to contribute to and enrich one another. Two main themes emerged from the participants' responses in the questionnaires, in the interviews, and from the minutes of the meetings.

The contribution of the workshop to the teachers and to their students

The teachers who participated in the workshop gained self confidence in the teaching and assessment methods of this new interdisciplinary curriculum and were motivated to try new content and teaching strategies. Moreover, they could better understand the advantages of the alternative assessment methods and were better prepared to use them.

We believe that teachers who are involved in such a process are satisfied with their work and their accomplishments and feel pride in their work.

Teachers' knowledge of science is based on previous experiences (von Glasersfeld, 1989) and on doing and experiencing (Gilmer, Grogan, & Siegel, 1996). Moreover, it was shown that personal involvement helps to reduce their anxiety in teaching an unfamiliar subject (Joyce & Showers, 1983). Therefore, teachers who actually develop the teaching strategies and assessment materials get a better understanding of how it should be taught and experience some kind of involvement: they are part of the curricular process (Parke & Coble, 1997), feel pride in their work, and become producers rather than consumers (Sabar & Shafriri, 1982). The new curriculum materials also appear to be effective vehicles for teachers' learning (Bybee & Loucks-Horsley, 2000). They were involved in the development of learning materials as well as the teaching strategies and assessment tools, which must be tailored adequately to the students' cognitive and affective characteristics, as mentioned by Ben-Peretz (1990). Hopefully, in the future, these teachers will serve as leaders and coordinators for similar workshops, and support those who will teach the STS module and use the alternative assessment method.

The active learning for which we strive in order to stimulate and motivate our students also stimulates and motivates the teachers. They better understand that the traditional paper and pencil assessment tools frequently used in science courses are inadequate for such an interdisciplinary program that is accompanied by a wide range of pedagogical interventions. As a result, the interest of these teachers' students in the process of learning increased, as well as their satisfaction from the learning materials, the learning strategies, the assessment methods, and the ongoing dialogue with their teachers. Since the students who studied the STS program were not science-oriented and their interest in scientific topics was limited, the variety of assignments enabled them to succeed with certain assignments and to do less regarding other activities. These results are in alignment with the main goal of the reform in science education in Israel - the need to make science an integral part of the education of all citizens (Tomorrow 98: Report of the superior committee on science mathematics and technology in Israel, 1992):

> *"Modern socioeconomic problems require an understanding of their scientific background. Other questions arise when we discuss the division of resources and world wealth, different environmental issues and other topics that require the individual to demonstrate an understanding based on having acquired a basic education the sciences."* (p. 3).

Challenges for teachers and for curriculum developers

The teachers who participated in the workshop were aware of the difficulties that could arise regarding the validity and reliability of the assessment tools. Thus, they made great efforts to improve and revise the assignments and rubrics according to the students' assignments. In fact, their anxiety about the alternative assessment methods gradually diminished when they realized that the continuous assessment of students' progress and achievements, consisting of detailed and clear assessment instructions, could present a broad, valid, and reliable picture of their students' knowledge and abilities.

To attain a wide range of assessment models, clearly time is needed in order to construct a supporting framework for science teachers (Westerlund, Garcia, Koke, Taylor, & Mason, 2002). Indeed, the teachers in the workshop were continuously supported and assisted by the workshop coordinators.

In summary, teachers who implement a new curriculum should receive sustained support in order to gain knowledge of different teaching strategies and of assessment skills. This can be done by attending professional development workshops that deal with those topics, which will consequently stimulate their creativity and diversify their instructional strategies in the classroom. Such skills should improve their ability to teach and understand their students' learning difficulties. Since they will better understand the goals, strategies, and rationale of the curriculum, they will feel more qualified to modify the curriculum as needed. We believe that such workshops help more teachers become producers rather than just consumers. Such efforts and reform in the way students are assessed (school-based assessment) necessitate support from other people not directly connected to the program, namely school headmasters, science coordinators, and government regional consultants (Krajcik, Mamlok, & Hug, 2001).

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Appendix 1

Rubrics given to the students for "Critical reading of scientific articles". The rubrics can be applied to a variety of teaching situations. If you take advantage of all the possibilities inherent in the format, your students will have a rich and powerful experience. If an assignment falls between categories, feel free to score it with in-between points.

Instructions	**Accomplished 5 points**	**Developing 3 points**	**Beginning 1 point**
Identify at least five scientific concepts whose meaning you do not know. Use reference books including dictionaries. Indicate the reference of each explanation.	Identification and explanation of at least five scientific concepts that are new to the student, indicating the reference to each explanation.	Identification and explanation of at least five scientific concepts that are new to the student, without indicating the reference to each explanation.	Identification and explanation of less than five scientific concepts that are new to the student, and lack references to each explanation.
Compile questions that raise criticism of the article's contents: *The questions should be formulated clearly *The questions should link the article's contents with other fields of knowledge studied in class. *The answers should appear in the article.	The questions are formulated clearly, link the article's contents with other fields of knowledge studied in class, and the answers appear in the article.	The questions are formulated clearly, link the article's contents with other fields of knowledge studied in class, but the answers do not appear in the article.	The questions are not formulated clearly, do not link the article's contents with other fields of knowledge studied in class, and the answers do not appear in the article.
Answer the questions that you compiled: Use precise, complete answers.	All the questions that the student compiled are answered clearly and precisely.	75% of the questions that the student compiled are answered clearly and precisely.	50% of the questions that the student compiled are answered clearly and precisely.

Comment: Only those students meeting the deadline are eligible for a temporary grade, the possibility of correction, and a final grade.

Enjoy your work!

Appendix 2

Rubrics given to the students for the essay ”The person behind the scientific endeavor”. The rubrics can be applied to a variety of teaching situations. If you take advantage of all the possibilities inherent in the format, your students will have a rich and powerful experience. If an assignment falls between categories, feel free to score it with in-between points.

Instructions	Accomplished 5 points	Developing 3 points	Beginning 1 point
Give a detailed background of the scientist’s era, consisting of scientific, technological, and societal aspects	A broad picture of the era, consisting of scientific, technological, and societal aspects	A partial picture of the era, lacking one of the aspects	A partial picture of the era, including only the scientific aspect
Write about the scientist’s life story (The Person Behind the Scientific Endeavor), consisting of the following aspects: *The scientist's scientific work and discoveries, and their contribution to society *The impact of society on the scientist's work *The scientist's personal life and its impact on his / her work	A description consisting of all the three aspects – scientific, societal, and personal	A partial description, consisting of only two of the aspects	A partial description, consisting only of the scientist's scientific work
Present an accurate list of references, according to those thatappear in the text, in alignment with your teacher's instructions, and organize them alphabetically	A full list of references, matched with those that appear in the text, according to the teachers' instructions, and organized alphabetically	A full list of references, which is not in alignment with the teacher's instructions, and not organized alphabetically	A partial list, which is not in alignment with the teacher's instructions, missing some references and not organize alphabetically
Organize your essay in a rational and aesthetic way. The essay should include: *All the chapters that were defined in the instructions given to the students *The ideas are presented rationally *The citations are placed correctly in the text	The essay is organized according to the given instructions, and is presented aesthetically	The essay lacks one of the components required	The essay lacks one of the components required, and is not presented aesthetically

Appendix 3

The teachers' attitudes regarding how the workshop contributed to their work

Statements related to the workshop	Fully agree (4)	Agree (3)	Agree a Little (2)	Do not agree (1)
<u>Knowledge</u>				
It affected my ability to teach the program.				
It helped me understand students' difficulties.				
It improved my teaching strategies.				
The assessment tools were beneficial for the students.				
<u>Motivation</u>				
It increased my interest in the program.				
It made me feel proud to have had an impact on the program.				
<u>Motivation regarding professional development</u>				
I would be happy to participate in a continuing workshop for developing learning materials.				
I would recommend that my friends participate in a similar workshop.				

Appendix 4

Students' satisfaction with the process of learning and their interest in it

Item	Fully agree (4)	Agree (3)	Agree a Little (2)	Do not agree (1)
The learning activities were diverse				
Learning was interesting				
The assignments were varied				
This learning method was satisfying				
It was clear to me how I got my grades				
I think that the grades I got in chemistry were fair				
I had an ongoing dialogue with my teacher				