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Factors Affecting Junior High School Students' Interest in Biology[1]

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ABSTRACT *Our study, conducted as part of the ROSE Project, on students' interest in biology at the end of their compulsory schooling in Israel, and its relation to their views on science classes, out-of-school experiences in biology, and attitudes to science and technology, showed that their overall interest in learning biology was relatively positive but not high; girls showed greater interest in it than boys. Students' interest in learning biology correlated closely with their negative opinions of science classes. These findings raise critical questions about the implementation of changes in the Israeli science curriculum in primary and junior high school, if the goal is to prepare the rising generation for life in a scientific-technological era. From deeper analysis of the results curricular, behavioral, and organizational changes needed to reach this goal were formulated.*

KEY WORDS: *Interest, junior high biology school students, biology.*

Introduction

As stated by Osborne, Simon and Collins (2003), "the investigation of students' attitudes towards studying science has been a substantive feature of the work of the science education research community for the past 30-40 years" (p. 1049). The importance of this investigation is stressed by a persistent decline in post-compulsory high school science enrolment over the last two decades. Concern has been voiced in many countries, including the UK (Smithers & Robinson, 1988), Australia (Dekkers & DeLaetter, 2001), Canada (Bordt, DeBroucker, Read, Harris & Zhang, 2001), India (Garg & Gupta, 2003), Japan (Goto, 2001), the USA (National Science Foundation, 2002), and every country in the European Union (Commission of European Communities, 2001). Students' increasing reluctance to choose science courses in their final years of secondary education has serious adverse implications for the health of scientific endeavour, but also for the scientific literacy of future generations. The endorsement of positive attitudes to science, scientists, and learning science, which has always been a constituent of sci-

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1. ROSE (The Relevance of Science Education) is an international project with about 40 participating countries. ROSE is organized by Svein Sjoberg and Camilla Schreiner at the University of Oslo and is supported by the Research Council of Norway. Reports and details are available at http;//www.ils.uio.no/english/rose/

ence education, is increasingly a subject of concern.

Many science educators attribute great importance to the affective domain (Baker & Doran, 1975; Schibeci, 1984; Gardner, 1985, 1998; Sjøberg, 2002, Oh & Yager, 2004). Shulman and Tamir (1973) argued that the affective outcomes of science instruction are at least as important as their cognitive counterparts. The affective domain is characterized by a variety of constructs, such as attitudes, preferences, and interests. Researchers' definitions of these constructs vary and consequently may be confusing. As reported extensively in the literature, students' early positive attitude to science subjects changes markedly in the upper grades, especially in chemistry and physics (Graber, 1993). Simpson, Koballa, Oliver and Crawley, (1994) published an extensive review on students' attitudes towards different science subjects. Generally, a negative attitude to a subject leads to lack of interest, and when subjects can be selected, as in senior high school, to avoiding the subject or course. Furthermore, a positive attitude to science "leads to a positive commitment to science that influences lifelong interest and learning in science" (Simpson & Oliver, 1990, p. 14). This is a reason why major science education reform efforts have emphasized the improvement of students' attitudes. For instance, Project 2061, a multiple-year project in science education, suggests that "science education should contribute to ... the development in young people of positive attitudes toward learning science" (American Association for the Advancement of Science, 1990, p. 184).

Several studies have identified a number of factors affecting students' attitudes to science in general. These can be largely categorized as gender, personality, structural variables, and curriculum variables. Gardner (1975) stated that "sex is probably the most important variable related to pupils' attitudes to science" (p. 22). Many studies (e.g., Menis, 1983; Sjøberg, 1983; Weinburgh, 1995; Francis & Greer, 1999; Jones, Howe & Rua, 2000; Sjøberg, 2000) have reported that males have more positive attitudes to science than females, while others found no statistically significant gender differences (Selim & Shrigley, 1983). Kahle and Meece (1994) published a wide-ranging review on gender issues related to students' attitudes to science subjects. Ormerod and Duckworth (1975) indicated the importance of distinguishing between the physical and biological sciences in respect of gender differences in attitudes to science. Gardner (1974), in a review of gender differences in achievement, attitudes, and personality of science students, stated that there were "clear differences in the nature of 'boys' and 'girls' scientific interests, boys expressing relatively greater interest in physical science activities, while girls are more interested in biological and social science topics" (p. 243). More recently, Osborne et al. (2003) showed that there was "still a bias against physical sciences held by girls, suggesting that at an individual level the overwhelming majority of girls still choose not to do physical science as soon as they can" (p. 1064). Their comprehensive literature survey shows that one of the main motivators of gender-related research in science education is the fact that there are few girls in technical and science-related occupations, while more qualified personnel are needed.

Israel took part in the Second International Science Study (SISS) in 1983-1984. In this study, 82% of the ten-year-olds and 66% of the 14-year-olds said that science was interesting. Among the 17-year-old students who elected to study science for their matriculation examination, 72% found the study of biology interesting, while only 48% found the study of physics interesting (Tamir, Levine, Lewy, Chen, & Zuzovsky, 1988). Shemesh (1990) found that Israeli junior high school girls tended to be more interested in languages, social studies, and humanities, while boys were more interested in science and technology. Furthermore, boys' interest in science and technology increased with age, while older girls became less interested. Likewise, the USA Department of Education (1997) reported that, while male and female seventh and tenth graders had similar positive attitudes toward science, high school seniors demonstrated a greater difference in these attitudes. Unfortunately, these less favourable attitudes of females often translate into less interest in science careers. Ironically, "young women begin to lose interest in science even when they perform as well, or even better in this subject as their male classmates" (Catsambis, 1995, p. 252).

According to Gardner and Tamir (1989a):

> The term "interest" usually refers to preference to engage in some types of activities rather than others. An interest may be regarded as a highly specific type of attitude: When we are interested in a particular phenomenon or activity, we are favorably inclined to attend to it and give time to it (p. 410).

Osborne et al. (2003) distinguished between "scientific attitudes," a multifaceted combination of the desire to know and understand, an inquiring approach to all statements, a search for data and their meaning, a demand for verification, a respect for logic, a consideration of premises and of consequences (Education Policies Commission, 1962), and "attitudes to science" as a school subject, that is, a set of affective behaviours towards science education, including interest in science. In this study, we deal with students' interest in biology as a school subject, that is, a combination of individual interest in biology, a short-term interest in certain biology topics produced by the interestingness of biology instruction in the sense of situational interest (Hidi & Andersen, 1992), and the social climate in biology classes. The combination of factors determining interest in biology as a school subject varies from one student to another.

Learning Biology in Israel

The study of preferences and interests in sciences is of vital importance in Israel, because the Ministry of Education has promoted major changes in the study of science in primary and secondary schools. New science curricula were introduced five years ago in order to "strengthen, deepen and improve the learning of mathematics, science and technology throughout the educational system, as a means of preparing the new generation for life in a scientific-technological era" (Tomorrow 98, 1992, p. 9). The recommendations of the Tomorrow 98 Report are in line with the worldwide trend towards the introduction of science, technology and society (STS) interrelations in science education. As a consequence, in Israel, all students follow a common interdisciplinary curriculum until the end of grade nine, which is the last year of junior high school. The main science subjects taught in the three years of junior high schools are: (a) biology and chemistry, including topics, such as the properties of water and its importance for plants, animals and human beings, mixtures and compounds, reproduction systems in plants, animals and human beings, the cell, nutrition, food types, photosynthesis, the human digestive system, processes in ecological systems and the human's dependence on the environment; heredity, genetics, DNA, chromosomes, meiosis and mitosis, and (b) physics topics, such as the structure, the properties, and the states of matter, mass and volume, interactions and forces, electrical current and voltage, forces between charged particles, the atom and the periodic table, energy, its transformation and conservation, forces and energy, Newton's laws. More than half the teachers are biology teachers, about a third are physics teachers, and very few are chemistry teachers.

In senior high school, Israeli students select a major field of study (biology, physics, and chemistry are the science subjects that can be chosen) either in grade ten or eleven, on which they are evaluated by a matriculation examination at the end of grade twelve. Tamir (1988) found that substantially more Israeli boys planned to study science-oriented subjects and to choose science-oriented careers than girls. Tamir, Arzi and Zloto (1974) already stated that:

> Low enrollments in ... sciences (are) a professional concern... primarily because of their adverse effect on the general education of high school students, but also because of their possible impact on vocational choice, notably that of potential teachers (p. 75).

Despite these reforms, over the last ten years only about 10% of the students chose biology as a major field of study. During these years, 60% to 66% of the biology students were girls and only 34% to 40% were boys. In parallel, almost the same number of students chose to major in physics, but with an inverse ratio of 70% boys and 30% girls. This is not the case all over the world. Spall, Barrett, Stanisstreet, Dickson and Boyes (2003) report that in England and Wales biology is much more popular than physics. For example, in 2002 some 52,100 students sat Advanced (A) level biology as against 31,500 who sat physics at A level (Publishers' Association/Education Publishers Council, 2003). This distribution is reflected in the numbers of students going on to take biology at university level. In 2001, there were 16,000 applications for university places in England and Wales in the biological sciences, compared with 10,700 applications for physics (Universities and Colleges Admission Service, 2003).

Overall, less than 25% of Israeli high school students major in science, including chemistry, in which there is an almost even gender distribution. This marks a dramatic decline from the situation in the 1980s, when only about half of the senior high school students took no science subject as a specialized field of study (Friedler & Tamir, 1990). This 'swing away from science' has been observed in several countries. In England and Wales, for instance, the percentage of students older than 16 studying science, or science and mathematics declined by more than one-half from the 1980s to the early 2000s (Osborne et al., 2003).

Since only those students who take science, or science and mathematics, are able (without further remedial courses) to pursue further scientific education and scientific careers, the decline in the number of science-based students as a proportion of all students eligible for higher education in the US and several European countries has raised concerns about their economic future and the scientific literacy of their population (Dearing 1996; National Commission on Mathematics and Science Teaching for the 21st Century, 2000).

The Present Study

ROSE (The Relevance of Science Education) is an international comparative project that applies a questionnaire with items that may shed light on the questions raised above.

Sjøberg, Schreiner and Stefansson (2004) stated:

The lack of relevance of the S&T curriculum is probably one of the greatest barriers for good learning as well as for interest in the subject. The ROSE project has the ambition to provide theoretical insight into factors that relate to the relevance of the contents as well as the contexts of S&T curricula. ROSE intends to provide a base for informed discussions on how to improve curricula and enhance the interest in S&T (p. 43).

The ROSE survey was conducted in Israel in January-March 2003. International data collection was finalized by June 2004. To the relevant questions students gave their responses on four-point Likert scales with categories of 'Not interested'-'Very interested,' 'Disagree'-'Agree,' 'Not important-Very important,' and 'Never-Often.' For each item, students were requested to indicate their response by marking the appropriate box, while the data entry was done on a scale from 1 to 4. The ROSE questionnaire, which was developed by an international advisory group of researchers in science education, comprises about 250 items. To handle this amount of material and to elevate the discussion from responses to single items to a more general level, questionnaire items were merged into composite variables or clusters and each cluster constituted one index. The indexes are latent variables not directly observed, but developed from a set of observed variables (the questionnaire items). The indexes are simply average item scores; each index contains a different number of items. Combinations of theoretical perspectives, the initial ideas of the questionnaire developers, exploratory factor analysis, and reliability analyses using Cronbach's alpha led to the structure of the current indexes: "What I want to learn about," "My future job," "Me and the environmental challenges," "My science classes," "My opinion about science and technology," "My out-of-school experiences," and "Me as a scientist" (the only open item). More details about the ROSE instrument, its theoretical background and development can be found in Schreiner and Sjøberg (2004), especially in Chapters 3 and 6, which include piloting of the Norwegian version of the questionnaire, three different international trials, and measures of validity, reliability and credibility of the English version, including factor analyses. Relying on it, we calculated the Cronbach's alpha coefficients as a measure of the internal consistency of the variables included in the present study (see next section).

This study randomly sampled 635 Israeli students (338 females and 297 males) in clusters (25 schools, one class at each school). The sample represents the population of all Israeli ninth-grade secular Jew students.

Results

We report here the results of a study, as part of the ROSE project, dealing with students' interest in learning biology at the end of their compulsory studies in Israel, their opinions about their science classes, their out-of-school experiences in biology, and their attitudes to science and technology.

How interested were students in learning about biology topics? The "Students' interest in biology" variable is a sub-index of the more comprehensive one: "What I want to learn about", comprising 31 items with Cronbach's alpha coefficient of 0.90. The "Students' opinions about their science classes" variable is also a sub-index of a more comprehensive one, "My science classes", comprising 14 items with Cronbach's a coefficient of 0.89. The "Students' attitudes toward science and technology" variable was defined by the questionnaire developers and comprises 16 items with Cronbach's alpha coefficient of 0.79. The "Students' out-of-school experience in biology" variable is a sub-index of a more comprehensive one, "My out-of-school experiences", comprising 13 items with Cronbach's alpha coefficient of 0.79. (See Appendix to characterize the different variables used in this study).

Students' overall interest in learning biology was relatively positive but not high (Mean = 2.71, S.D. = 0.50); their attitude to science and technology was somewhat lower than their interest in biology (Mean = 2.65, S.D. = 0.43); their opinions about their science classes (Mean = 2.19, S.D. = 0.69) and their out-of-school experience in biology (Mean = 2.15, S.D. = 0.49) were generally low. Table 1 shows the difference between boys and girls for these variables.

Table 1

Comparison Between Boys and Girls

	Girls	Boys	t-test	Cohen's size effect
Students' interest in biology	Mean = 2.82 S.D. = 0.48	Mean = 2.58 S.D. = 0.49	t = 6.01 p-value < .01	d = .495
Students' attitudes to S&T	Mean = 2.60 S.D. = 0.44	Mean = 2.70 S.D. = 0.43	t = 2.97 p-value = .03	d = .236
Students' opinions about science classes	Mean = 2.09 S.D. = 0.70	Mean = 2.30 S.D. = 0.66	t = 3.84 p-value < .01	d = .306
Students' out-of-school experiences in biology	Mean = 2.18 S.D. = 0.50	Mean = 2.12 S.D. = 0.48	t = 1.57 p-value = .12	d = .122

Statistically significant differences are evident in students' interest in biology, their attitudes to science and technology, and their opinions about science classes, but not in their out- of-school experiences in biology. Girls showed a higher interest in biology with a medium ($d \simeq 0.5$) effect size (Cohen, 1988). Boys held more positive attitudes to science and technology and more favourable opinions about science classes than girls, but with a smaller effect size. In out-of-school experiences in biology there was no statistical difference between boys and girls. Sjøberg et al. (2004), in their first review of the international data, reported that

> Some challenges in S&T education seem to be common for most countries. Other challenges seem to be more pronounced in certain countries than others. For instance, the lack of interest in S&T studies, and the possible hostility or disenchantment with S&T seem to be more pronounced in many highly developed countries than other parts of the world. The 'rich' OECD countries (US, Canada, Western Europe, Australia, Japan) seem to have such challenges, while such trends are to a less extent found in economically less developed countries of Asia, Africa, Oceania, and Latin America (p. 44).

How is students' interest in biology related to the other three variables? We calculated the Pearson correlation coefficients between them, as it is shown in Table 2.

Table 2
Pearson Correlation Coefficients

	Students' interest in biology	Students' attitudes to S&T	Students' opinions about science classes	Students' out-of school experiences in biology
Students' interest in biology	1.000	0.170 < .01	0.327 < .01	0.283 < .01
Students' attitudes to S&T	-	1.000	0.388 < .01	0.016 = .69
Students' opinions about science classes	-	-	1.000	0.174 < .01
Students' out-of-school experiences in biology	-	-	-	1.000

We found a relatively strong correlation between students' interest in learning biology and negative opinions of science classes than between more positive attitudes to science and technology and limited out-of-school experiences in biology. We also performed a multiple regression, whose results appear in Table 3.

Table 3
Multiple Regression Model – Dependent Variable: Students' Interest in Biology

Model	R	R Square	Adjusted R Square	p- value
Students' opinions about science classes	.352	.124	.122	< .01
Gender	.453	.205	.203	< .01
Students' out-of-school experiences in biology	.496	.246	.243	< .01
Students attitudes to S&T	.506	.256	.251	< .01

Students' opinions of their science classes, their gender, their out-of school experiences in biology, and their attitudes to science and technology proved significant factors, explaining about 25% of students' interest in biology. (Students' opinions of their science classes contributed 12%, their gender 8%, their out-of-school experiences in biology only 4%, and their attitudes to science and technology less than 1%.)

We also found that only 195 students (31% of the sample) were interested in biology, that is, they marked on average that they were "interested" or "very interested" in the different biology topics presented to them in the questionnaire. The gender distribution among them was 132 girls (68%) and 63 boys (32%), with no statistically significant difference in their interest in biology. The variables that most correlated with it were their poor opinions about their science classes (Pearson correlation coefficient - $r = 0.232$, p-value = .001) and their very limited out-of-school experience in biology ($r = 0.212$, p-value = .003). In this group, boys also had statistically significant more favourable opinions of their science classes than girls ($t = 3.19$, p-value = .002), but there was almost no difference in their limited out-of-school experiences in biology (Boys' mean = 2.28, S.D. = .51; Girls' mean = 2.31, S.D. = .50).

Furthermore, we looked for the biology topics boys and girls were more interested and more uninterested in (see Tables 4 and 5). We concluded that the two groups shared five of the six most interesting topics, although boys were significantly less interested than girls in all of them, with considerable size effects ($d \simeq 0.8$ – large size effect), as can be seen in Table 4. They also shared four of the five most uninteresting topics, without any statistical difference in the two most uninteresting ones.

Table 4
Girls' and Boys' Most Interesting Biology Topics

Subject	Girls' interest		Boys' interest		t-test	Cohen's
	Mean	S. D.	Mean	S. D.		size effect
Why we dream while we are sleeping, and what the dreams may mean	3.64	0.70	2.96	1.00	t = 9.70 p-value < .01	d = .785
Cancer, what we know and how we can treat it	3.38	0.88	2.94	0.97	t = 5.93 p-value < .01	d = .474
How different narcotics might affect the body	3.34	0.89	2.97	1.02	t = 4.86 p-value < .01	d = .387
What we know about HIV/AIDS and how to control it	3.33	0.88	2.91	1.00	t = 5.72 p-value < .01	d = .448
Sexually transmitted diseases and how to be protected against them	3.29	0.89	2.94	0.96	t = 4.79 p-value < .01	d = .378

Girls were also interested in "How alcohol and tobacco might affect the body" (Mean = 3.33, S.D. = 0.89) and boys in "Biological and chemical weapons and what they do to the human body" (Mean = 3.25, S.D. = 0.95).

Table 5
Girls' and Boys' Most Uninteresting Biology Topics

Subject	Girls' interest		Boys' interest		t-test	Cohen's
	Mean	S. D.	Mean	S. D.		size effect
How plants grow and reproduce	1.76	0.82	1.76	0.83	N.S.	N.R.
Plants in my area	1.94	0.97	1.96	0.96	N.S.	N.R.
How people, animals, plants and the environment depend on each other	2.25	0.98	2.06	0.88	t = 2.56 p-value = .011	d = .205
Risks and benefits of food additives	2.28	1.00	2.08	0.98	t = 2.49 p-value = .013	d = .202

N.S. = not significant
N.R. = not relevant

We looked also for the five most positive opinions of boys and girls on science and technology; these were all shared by the two groups, as may be seen in Table 6.

Table 6
Girls' and boys' most positive attitudes to science and technology

Opinion	Girls		Boys	
	Mean	S. D.	Mean	S. D.
S&T will find cures for diseases such as HIV/ AIDS, cancer, etc.	3.53	0.72	3.45	0.72
A country needs S&T to become developed	3.48	0.79	3.47	0.77
Thanks to S&T, there will be greater opportunities for future generations	3.46	0.77	3.35	0.78
S&T are important for society	3.30	0.89	3.34	0.82
Scientific theories develop and change all the time	3.25	0.89	3.16	0.89

The findings of this study raise serious questions about the implementation of the changes made in the Israeli science curriculum in primary and junior high school. Such is the case if indeed the goal is to prepare the new generation for life in a scientific-technological era, as stated by the Tomorrow 98 Report (1992).

Discussion and Educational Implications

There is an extensive literature on attitudes, interests, and enrolments in science (Gardner, 1975; Ormerod & Duckworth, 1975; Schibeci, 1984; Simpson et al., 1994). It seems natural to assert that students' enrolment will be influenced by their interests, "since enrolling for a subject at a stage, when it becomes optional, is an obvious way of expressing one's interest" (Gardner & Tamir, 1989b, p. 426). As Sjøberg (1983) noted, much of what people in the industrialized world do in their daily lives is probably partly governed by their interests. Ormerod and Duckworth (1975) pointed out that interest in science appears to be aroused at an earlier age than interest in other curriculum areas, suggesting that primary science experience might be important for future students' long-term interest in the subject. More lately, Craig and Ayres (1988) stated that British girls in most of the primary classes expressed greater interest in studying further school science topics than the boys. But they added:

> *The level of interest amongst the girls, which at primary school had been higher than for boys, appeared to have dropped considerably so that the girls who had greatest primary science experience now gave the lowest response to questions about interest in future school science topics (p. 423).*

This feature of a low percentage of girls learning science and technology subjects at the high school level, and a low number of women in professions related to science and technology at the academic and industrial levels, is well known around the world (NAEP, 1983; Lockheed, Thorpe, Brooks-Gun, Casserly & McAlloon, 1985). In recent years, different lines of investigation have been developed that found similar results of the causes of students' decreasing interest in the study of sciences, as well as possible solutions. Similarly, changes in society and in the interrelation between science and technology, and also the disconnection between scholastic science and the reality of a scientifically-oriented society have necessitated the re-definition of objectives in the teaching of science. The changes in the mutual relation between science, technology and society, and the disconnection between school science and daily life have converged in a field that has been fruitful and that appears to be an effective strategy in science education. This is evinced by the enormous quantity of literature on this subject (Solomon & Aikenhead, 1994) and by the development of numerous projects and studies related to the study of science, technology, and society (STS) interactions in education. The development of the different STS projects (like the Tomorrow 98 Report) attempts to bring science teaching closer to the needs of the science student as a member of a society that is becoming more and more technologically developed, and to remove gender bias in subject choice by presenting more balanced science courses.

So, why is students' interest in biology at the end of junior high school is not as high as that found in the above studies, with less than a third of them 'interested' or 'very interested' in biology? What can be done to increase the number of students, especially boys, who choose biology as their major field of study in secondary school? In our study, we found the factor most adversely affecting students' interest in biology to be their poor opinion of science classes in junior high school. In most countries, the evidence would indicate that children enter junior high school with a highly favourable attitude to science and interest in science, both of which are eroded by their experience of school science, particularly for girls (Kahle & Lakes, 1983). Various researchers (Woolnough, 1994a; Sundberg et al., 1994; Hendley, Parkinson, Stables & Tanner, 1995) concluded that the quality of school science teaching is the significant determinant of attitude to the subject. Many years ago, Choppin and Frankel (1976) found that more than half the lessons reported by students as their 'peak learning experiences' in biology were in laboratory sessions, when the students themselves conducted experiments. Nevertheless, biology lessons in the secondary school typically begin with the teacher explaining what the class is going to do. Students have no choice of topics and the teacher rarely uses their ideas. In the laboratory, students usually work on problems set by the teacher, and only sometimes work out their own method. Instead, they follow written instructions or watch the teacher doing demonstrations. They often copy notes from the blackboard and have regular tests (Tamir & Amir, 1987). Osborne and Collins (2000) claim that for many the contemporary curriculum places too heavy an emphasis on undemanding activities such, as recall and copying, and it lacks intellectual challenge.

From the results of this study, it can be seen that students were interested in subjects related to their personal life and needs; while there was a leaning to 'human biology', students were less interested in animals and plants. If schools want to offer meaningful experiences to their students and to minimize alienation and indifference, students' preferences have to be considered carefully. We agree with Armstrong's (1973) old recommendation that high school students should be allowed to choose learning topics. According to him, the interest shown by students in different subject matter should count in the pedagogical thinking of those planning curricula for schools. Thought should be given to students' choices and preferences in setting goals, content, and learning ways. Teachers should look for a permanent path of interaction to discover which topics their students want to study in addition to the formal curriculum, and should devote time to instruction in such topics.

We also found that students with a positive view of science, who are fascinated by natural phenomena, and who recognize the general importance of science or the role that science may play in their future, may nevertheless not be so interested in the kind of biology they encounter in the classroom. According to Osborne et al. (2003),

> This disparity ... between the high-tech and socially relevant perception of science held by students and the more theoretical, decontexualized version of school science promulgated by teachers, identifies a major gulf between teachers and their students that may impede effective communication. In essence, the vision that school science offers is a backward-looking view of the well-established scientific landscape, whereas, in contrast, what appeals to and excites students is the 'white heat' of the technological future offered by science. In short, to capitalize on students' interests, school science needs to be less retrospective and more prospective. (p. 1062)

According to Howes (2002), science education reforms basically ignore the very people they are intended to benefit. Although girls and boys in some domains have a somewhat different interest structure, there is a considerable overlap in their interest in biology topics. Biology as it is taught in the majority of junior high school courses does not really take these interests into account. Adaptation of the curriculum by adding topics students are interested in could be a very effective means to solve some of the current problems of biology education. Haussler and Hoffman (2000) believe that "a better fit between curriculum and students' interests could lead to better results in terms of cognitive as well as affective outcomes" (p. 697).

Perhaps the most powerful message to emerge from our study, and from many of the researches mentioned above, is the need to concentrate on ways to develop students' affective response so that they find personal satisfaction in doing science and therefore want to continue with it. In addition, as mentioned, here in Israel and also in the UK (Osborne et al., 2003), biology in many junior high classes is taught by teachers without expert knowledge and with little enthusiasm; the quality of teaching and learning is thereby further debased. Such teachers, lacking confidence and familiarity, fall back on didactic modes of teaching that only increase students' reluctance still more. We clearly need to make the curriculum as relevant and as exciting for students as possible, but as Woolnough (1994b) has noted, without lively teachers, with the time and inclination to teach biology in a stimulating manner, the number of students who 'switch on' to biology will not rise.

We also interviewed most of the schools principals whose classes participated in this study. They indicated that although the curriculum was changed according to the recommendations of the Tomorrow 98 (1992) Report, in many junior high schools the time allocated to science and technology classes was significantly less than that proposed by the report, 12 instead of 18 hours during the three years of junior high school. Secondary school teachers in Spain stated this also (Solbes & Vilches, 1997). Furthermore, many teachers lack the training needed for teaching interdisciplinary subjects. If we want the new science and technology curriculum to succeed so that students are more science-literate and increase their interest in biology, these shortcomings must be overcome.

Since students' perception of science is probably influenced by the particular curriculum that is implemented in school, and the teacher's image and behavior influence this perception, we concluded that the following changes are needed:

1. Curricular changes: adding to the biology lessons biology-related topics of equal interest to girls and boys,
2. Behavioural changes: making teachers more proficient in teaching biology in an interdisciplinary way, and by a constructivist approach in regular classes and in the laboratory.
3. Organizational changes: allocating the appropriate time needed for science and technology classes in junior high school, as proposed by the Tomorrow 98 (1992) Report.

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APPENDIX

Students' interest in biology (Cronbach's alpha = 0.90)

How interested are you in learning about the following?

A07. How the human body is built, and functions.

A08. Heredity, and how genes influence how we develop.

A09. Sex and reproduction.

A10. Birth control and contraception.

A11. How babies grow and mature.

A12. Cloning of animals.

A13. Animals in other parts of the world.

A14. Dinosaurs, how they lived and why they died out.

A15. How plants grow and reproduce.

A16. How people, animals, plants and the environment depend on each other.

A20. How animals use colours to hide, attract or scare.

A26. Epidemics and diseases causing large losses of life.

A29. Deadly poisons and what they do to the human body.

A32. Biological and chemical weapons and what they do to the human body.

A37. What to eat to keep healthy and fit.

A38. Eating disorders like anorexia and bulimia.

C13. Why we dream while we are sleeping, and what the dreams may mean.

E05. What can be done to ensure clean air and safe drinking water.

E07. How to control epidemics and diseases.

E08. Cancer, what we know and how we can treat it.

E09. Sexually transmitted diseases and how to be protected against them.

E12. How alcohol and tobacco might affect the body.

E13. How different narcotics might affect the body.

E18. Medicinal use of plants.

E23. How my body grows and matures.

E24. Animals in my area.

E25. Plants in my area.

E31. Biological and human aspects of abortion.

E32. How gene technology can prevent diseases.

E35. Risks and benefits of food additives.

Students' opinions about their science classes (Cronbach's alpha = 0.89)

To what extent do you agree with the following statements about the science that you may have had at school?

F02. School science is interesting.

F04. School science has opened my eyes to new and exciting jobs.

F05. I like school science better than most other subjects.

F06. I think everybody should learn science at school.

F07. The things that I learn in science at school will be helpful in my everyday life.

F08. I think that the science I learn at school will improve my career chances.

F09. School science has made me more critical and sceptical.

F10. School science has increased my curiosity about things we cannot yet explain

F11. School science has increased my appreciation of nature.

F12. School science has shown me the importance of science for our way of living

F13. School science has taught me how to take better care of my health.

F14. I would like to become a scientist.

F15. I would like to have as much science as possible at school.

Students' attitude to science and technology (Cronbach's alpha = 0.79)

To what extent do you agree with the following statements?

G01. Science and technology are important for society.

G02. Science and technology will find cures to diseases such as HIV/AIDS, cancer, etc.

G03. Thanks to science and technology, there will be greater opportunities for future generations.

G04. Science and technology make our lives healthier, easier and more comfortable.

G05. New technologies will make work more interesting.

G06. The benefits of science are greater than the harmful effects it could have.

G07. Science and technology will help to eradicate poverty and famine in the world.

G08. Science and technology can solve nearly all problems.

G09. Science and technology are helping the poor.

G10. Science and technology are the cause of the environmental problems.

G11. A country needs science and technology to become developed.

G12. Science and technology benefit mainly the developed countries.

G13. Scientists follow the scientific method that always leads them to correct answers.

G14. We should always trust what scientists have to say.

G15. Scientists are neutral and objective.

G16. Scientific theories develop and change all the time.

Students' out-of-school experiences in biology (Cronbach's alpha = 0.79)

How often have you done this outside school?

H05. Collected different stones or shells.

H06. Watched (not on TV) an animal being born.

H07. Cared for animals on a farm

H08. Visited a zoo

H09. Visited a science centre or science museum.

H10. Milked animals like cows, sheep or goats.

H11. Made dairy products like yoghurt, butter, cheese or ghee.

H13. Watched nature programmes on TV or in a cinema.

H14. Collected edible berries, fruits, mushrooms or plants.

H17. Planted seeds and watched them grow.

H18. Made compost of grass, leaves or garbage.

H25. Cleaned and bandaged a wound.

H28. Taken herbal medicines or had alternative treatments (acupuncture, homeopathy, yoga, healing, etc.).