# Israeli Students' Interest in Physics and its Relation to their Attitudes towards Science and Technology and to their own Science Classes[1]

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Many science educators attribute a great importance to the affective domain (Baker & Doran, 1975; Schibeci, 1984, Sjoberg, 2002). Shulman & Tamir (1973) have 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. The definition of these constructs by different researchers varies and consequently may be confusing. As reported extensively in literature, students' originally positive attitude towards science subjects changes markedly in the upper grades, especially in chemistry and physics (Graber, 1993). Simpson et al. (1994) have published an extensive review about students' attitudes towards different science subjects. Generally, a negative attitude towards a subject leads to a lack of interest and, when the subjects can be selected as in senior high school, to avoiding the subject or course.

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; Sjoberg, 1983; Francis & Greer, 1999) have reported that males have more positive attitudes to science than females while others found no statistically significant gender differences (Selim & Shrigley, 1983). Kahle & Meece (1994) have published an extensive review about the gender issues related to students' science attitudes towards science subjects. Ormerod & Duckworth (1975) indicated the importance of distinguishing between the physical and biological sciences when gender differences in attitudes to science are considered. Gardner (1974), in a review of gender differences in achievement, attitudes and personality of science students, stated that there are "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). These findings were corroborated recently by Sjoberg (2002).

Israel took part in the Second International Science Study (SISS) in years 1983-1984. In this study 82% of the 10 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 toward the matriculation examination, 72% found the study of Biology interesting while only 48% found the study of physics interesting (Tamir et al., 1988). Shemesh (1990) found that Israeli junior high school girls tend to be more interested in language, social studies and humanities, while boys are more interested in science and technology. Furthermore, boys' interest in science and technology increased with age while older girls became less interested. In the same trend, the U. S. Department of Education (1997) reported that "while male and female seventh and tenth graders have similar positive attitudes toward science, high school seniors demonstrate a greater gap" in these attitudes. Unfortunately, these less favorable 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).

According to Gardner & 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)

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[1] The study was carried out in the framework of the international ROSE Project

## The learning of physics in Israel

Today, in Israel all students follow a common curriculum until the end of grade nine which is the last year of junior high school. In senior high school, Israeli students select a major field of study, either in grade ten or eleven, on which they are evaluated by a matriculation examination at the end of the 12$^{th}$ grade. Tamir (1988) found that substantially more Israeli boys plan to study science-oriented subjects and choose science-oriented careers than girls. Tamir et al. (1974) have already stated that:

> Low enrollments in the physical 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).

The study of preferences and interests in physics 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 world widespread trend towards the introduction of science, technology and society (STS) interactions in science education. Despite that, in the last three years only 9 to 10% of the students chose physics as a major field of study. In these years, 70% of the physics students were boys and only 30% girls; these are the same figures as those that were recorded about 25 years ago.

## The ROSE Project

ROSE (The Relevance of Science Education) is an international comparative project that makes use of a questionnaire with items that shed light on the questions raised above. The ROSE survey was conducted in Israel during January-March 2003; international data collection was finalized by June 2004. In the relevant questions students gave their responses using four-point Likert scales with categories for ‘Not interested’-‘Very interested’, ‘Disagree’-‘Agree’. For each item, students were requested to indicate their response by selecting an appropriate box while the data entry was done on a scale from 1 to 4. The ROSE questionnaire that was developed by an international advisory group of very well known researchers in science education comprises about 250 items. Both for overcoming the amount of material and for being able to lift the discussion up from responses to single items to a more general level, questionnaire items were merged into composite variables or clusters; 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 $\alpha$ have 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).

## Israeli students’ interest in physics

The focus of this paper was on a sample of 635 Israeli students (338 females and 297 males) randomly sampled in clusters (25 schools, one class at each school). The sample represents the population of all Israeli 9$^{th}$ grade students. In the present study, we report the results of a study dealing with students' interest in physics at the end of their compulsory studies in Israel, their attitude toward their science classes and their opinion about science and technology, carried out in the framework of the ROSE Project (See Appendix in order to characterize the different indexes used in this study). How interested are students in learning about physics topics? One index in the questionnaire is an inventory of possible topics to learn about. Students were requested to select the appropriate category for how interested they are in learning about the topic. “Students’ interest in physics” is a sub-index of this more comprehensive index: “What I want to learn about”, comprising 22 items with a Cronbach $\alpha$ coefficient of 0.88. Students’ overall interest in physics was exactly in the middle of the scale, 2.5, with boys showing a higher interest (2.64) than girls (2.37), a statistically significant difference ($t = 6.13$, $p$-value $< .001$). Students’ attitude toward their science classes index was defined a-priori by the questionnaire developers and comprised 14 items with a Cronbach $\alpha$ coefficient of 0.89. Students’ attitude towards their science classes was generally low (2.19), with boys showing a more positive attitude (2.3) than girls (2.09), a statistically significant difference ($t = 3.84$, $p$-value $= .001$). Students’ opinion about the science and technology index was also defined a-priori by the questionnaire developers and comprised 16 items with a Cronbach $\alpha$ coefficient of 0.79. Students’ opinion about science and technology was somewhat higher than their attitude towards science classes (2.65), with a very little but statistically significant difference ($t = 2.97$, $p$-value $= .003$) between boys (2.7) and girls (2.6) due to the size of the sample. How is student interest in physics related to the other two indexes? We calculated the Pearson correlation coefficients between them and found that there is a stronger correlation between students’ middle interest in physics and their negative attitude towards science classes (Pearson coefficient = 0.52, $p$-value $< .001$), than with their more positive opinion about science and technology (Pearson coefficient = 0.38, $p$- value $<$ .001). Moreover, using a multiple regression model we found that students’ attitude towards science classes and students’ gender are significant factors explaining about 30% of students’ “neutral” interest in physics (students’ attitude towards science classes contributing 27% and students’ gender 3.3%). Findings from this study raise serious questions about the implementation of the changes made in the Israeli science curriculum in primary and junior high school, 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**

There is an extensive literature on attitudes, interests and enrollments in science (Gardner, 1975; Ormerod & Duckworth, 1975; Schibeci, 1984; Simpson et al., 1994). It seems natural to assert that students’ enrollment 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 Sjoberg (1983) noted, much of what people in the industrialized world do in their daily life is probably partly governed by their interests. Ormerod & Duckworth (1975) pointed out that interest in science appears to be aroused at an earlier age than interests in other curriculum areas, suggesting that primary science experience might be important to future students' long-term interest in the subject. More lately, the study of Craig & Ayres (1988) stated that British girls in most of the primary classes expressed more 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).

In a study carried out in Germany, Haussler (1987) confirmed the general trend found in many other studies, which is that the overall interest in physics decreases as students grew older and that boys are more interested than girls. However, he found that this drop in interest is rather moderate; it is most pronounced during the interval between 12 and 13 years of age, i.e., at the age at which formal instruction in physics starts, and is fairly level afterwards. A

possible interpretation of this coincidence would be that prior to any physics instruction students have high expectations with respect to physics, which are not quite met by the kind of physics lessons they experience later in school. The phenomena that a low percentage of girls learn science and technology subjects at the high school level, and a low number of women is found in professions related to science and technology at the academic and industrial levels is well known around the world (NAEP, 1983; Lockheed et al., 1985) Whitten et al. (2003) reported that in 1998, in the United States, women received about 40% of the bachelor's degrees in mathematics and chemistry, but only 19% of the bachelor's in physics. That under representation worsens at higher levels: The same year, women constituted 13% of physics PhD recipients and 8% of physics faculty members. According to NSF, the community of working PhD-level physicists in 2000 was 84% white and 93% male.
In recent years, different lines of investigation have been developed, coinciding in analyzing the causes of the decreasing interest of students toward the study of physics, as well as possible solutions. In the same manner, the 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 forced a reestablishment of the objectives in the teaching of science. Both paths have converged in a field that has been fruitful and that appears to be an effective strategy in science education, as evidenced by the enormous quantity of literature in regard to this subject (Solomon & Aikenhead, 1994), and the development of numerous projects and studies related to the treatment of science, technology, and society (STS) interactions in education. The development of the different STS projects (like the Tomorrow 98 Report) attempts to bring the teaching of science closer to the needs of the science student as a member of a society that is more and more technologically developed.
So, what is the reason that students' interest in physics at the end of junior high school is so low? What can be done in order to increase the number of students, especially girls, electing physics as their major field of study in secondary school?
On one hand, Solbes & Vilches (1997) found that despite considering that the absence of STS interactions in science education is a cause of the lack of interest among students, most secondary teachers in Spain (89.2%) ignore these aspects when analyzing materials used routinely in physics classes. They stated that:

> It is to be expected that, if the majority of teachers do not consider interactive STS aspects a necessary element, then they evidently do not transmit a complete and contextualized vision of science to their students. Many explain that they do not open up the discipline to daily life because of structural problems relating to their timetable (lack of time). (p. 380)

On the other hand, Haussler & Hoffman (2000) claimed that:

> The misfit between the actual curriculum and students' interest might be responsible to a great deal for the rather poor results of physics instruction. Or stating this in a more positive way, a better fit between curriculum and students' interests could lead to better results in terms of cognitive as well as affective outcomes. (p. 697)

In the wake of the results obtained in the present study, we looked for the physics subjects boys and girls are more interested in, and we came to the conclusion that four of the five more interesting subjects are shared by the two groups, as can be seen in the following table:

| Subject | Girls' interest | | Boys' interest | |
|---|---|---|---|---|
| | Mean | S. D. | Mean | S. D. |
| How it feels to be weightless in space | 3.29 | 0.98 | 3.21 | 1.05 |
| How meteors, comets or asteroids may cause disasters... | 2.91 | 1.02 | 3.10 | 0.96 |
| Black holes, supernovas and other spectacular objects… | 2.68 | 1.16 | 3.12 | 1.04 |
| How the atom bomb functions | 2.62 | 1.16 | 3.40 | 0.90 |

Girls are also interested in "How the eye can see light and colours" (Mean = 2.81, S.D. = 0.99) and boys in "Rockets, satellites and space travel (Mean = 3.11, S.D. = 1.05).
We looked also for the five most positive opinions of boys and girls about science and technology and we found that these are completely shared by the two groups, as may be seen in the following table:

| Opinion | Girls | | Boys | |
|---|---|---|---|---|
| | Mean | S. D. | Mean | S. D. |
| S&T will find cures to diseases such as HIV/AIDS … | 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 ... | 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 |

We may reckon that students that hold a positive opinion about science, that are fascinated by natural phenomena and recognize the general importance of science or the role that science may play in their future, may nevertheless not be interested in the kind of physics they encounter in the classroom. According to Howes (2002), "science education reforms fundamentally ignore the very people they are meant to benefit". Physics as it is taught in the majority of physics courses does not seriously take into account students' interests. Adaptation to the interest of students could be a very effective means to solve some of the current problems of physics education.
Moreover, we can see that:

- Although girls and boys in some domains have a somewhat different interest structure, there is a considerable overlap in interest.
- Girls as well as boys have difficulties in experiencing their physics class as being interesting.
- For both sexes their opinion about science is not a strong predictor of their interest in physics as a school subject. According to Haussler & Hoffman (2002):

> The best predictor of [students' interest in physics as a school subject] is the self-concept a student has from his or her confidence in being successful in the physics class… In comparison with their male classmates, on average girls have a physics-related self-concept that is ill developed. (p. 872)

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 for the science and technology classes is significantly less than that proposed by the report, as it has been also reported by Spanish secondary teachers (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 will be more science-literate and increase their interest in physics, these shortcomings must be taken into account.
We therefore came to the conclusion that the following changes are needed:

1. Curricular changes: shaping physics lessons to the physics related interests shared by girls and boys
2. Behavioral changes: making teachers more proficient in teaching interdisciplinary science and technology subjects and in supporting girls to develop a positive physics-related self-concept.
3. Organizational changes: allocating the appropriate time needed for the science and technology classes in junior high school.

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**Appendix**

Students' interest in physics

How interested are you in learning about the following?

A01. Stars, planets and the universe
A17. Atoms and molecules
A18. How radioactivity affects the human body
A19. Light around us that we cannot see (infrared, ultraviolet)
A21. How different musical instruments produce different sounds
A22. Black holes, supernovas and other spectacular objects in outer space
A23. How meteors, comets or asteroids may cause disasters on earth
A30. How the atom bomb functions
A34. How it feels to be weightless in space
A35. How to find my way and navigate by the stars
A36. How the eye can see light and colours
A44. Rockets, satellites and space travel
A45. The use of satellites for communication and other purposes
A46. How X-rays, ultrasound, etc. are used in medicine
A48. How a nuclear power plant functions
C02. Optical instruments and how they work (telescope, camera, microscope, etc.)

C16. Why the stars twinkle and the sky is blue
C17. Why we can see the rainbow
E02. How the sunset colours the sky
E20. How energy can be saved or used in a more effective way
E21. New sources of energy from the sun, wind, tides, waves, etc.
E27. Electricity, how it is produced and used in the home

Students' attitude towards their science classes
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' opinion about science and technology
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

**Keywords** students' interest in physics, students' attitude toward their science classes, students' opinion about science and technology, science and technology curriculum