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A Conceptual Model (The Six Mirrors of the Classroom) and It's Application to Teaching and Learning About Microorganisms

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Abstract In this paper a conceptual model of instruction "the six mirrors of the classroom" used as a frame for teaching a learning topic, the microorganisms are depicted. The paper consists of four sections: (a) the six mirrors of the classroom model (SMC); (b) the SMC as implemented in the expository and cooperative modes of instruction in classrooms and results; (c) a "Journey of Inquiry into the Wonderful World of Microorganisms" (JIWWM), developed according to the Science–Technology–Environment–Peace–Society (STEPS) approach; and (d) teaching and learning the JIWWM, in ninth-grade classes, within the SMC model. The results show that science topic can be taught in the frame of the mirrors of the classroom. When the instructional goals of the teachers used the mirror "1, classroom organization" and mirror "6, pupils' social behavior" and the third ring around the all six mirrors cooperative skills were practiced, academic outcomes were achieved, and attitudes toward environmental preservation and peace improved. The SMC model can serve as a valuable tool for teachers, since it can design their teaching and learning settings in a more controlled environment, in terms of objectives, teachers' and students' social behaviors, and academic outcomes.

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Introduction

What do students do in the classroom while engaging in academic work is an obvious question, teachers and researchers constantly ask.

Many respond that students learn, study, listen to the teachers, ask and answer questions, write, read, and do home work. Others add that they also chat, daydream, and wait for the bell to ring. All of these learning activities have been described in many quantitative and qualitative studies, as Hertz-Lazarowitz (1992) noted. From the 1960s to the 1970s classroom research focused on teacher behavior, on the assumption that teachers have to practice a variety of instructional behaviors in order to keep students alert, interested, and engaged in academic work (Flanders 1970). The focus subsequently shifted to students' behavior—a trend that was influenced by Good and Brophy (1973) work, "Looking in Classrooms". This trend emphasized descriptive-phenomenological methods by analyzing teacher–student communication regarding the learning process in different classroom settings. Today's classroom is perceived as a complex social and academic system whose main components are the physical organization of the class, the learning task, the instructional and communicative patterns of the teacher, and the social and academic behaviors of the students. The theories that have contributed to the view that students are and can be active participants in the instructional/learning process are the social-constructivist theory (Vygotsky 1978), the social

psychology of contact (Allport 1954), and cooperation (Deutch 1949). Cooperative learning combines these theoretical frameworks into practical instruction in which attention to student behavior is observed as a factor that can have an impact on the complexity of the social learning environment (Lazarowitz and Hertz-Lazarowitz 1998).

The Six Mirrors of the Classroom model (SMC) developed by Hertz-Lazarowitz (1992) describes the richness and complexity of the classroom in its relation to students' behavior. This model suggests that the following four dimensions—physical organization, learning task structure, teacher instruction, and communicative behaviors—are interrelated and function simultaneously in each classroom. By studying the four dimensions mentioned above, the two other classroom dimensions, students' academic work and social behavior, can be predicted.

In this study, the SMC (Hertz-Lazarowitz 1992) was used as a framework for teaching and studying a learning unit, "Microorganisms"/"A Journey of Inquiry into the Wonderful World of Microorganisms", written for middle-school students (Khalil 2002a, b)).

The paper consists of four sections:

(1) The Six Mirrors of the Classroom Model (SMC), developed by Hertz-Lazarowitz (1992).
(2) The SMC as implemented in the expository–frontal and cooperative modes of instruction/learning in classrooms and study's results.
(3) "A Journey of Inquiry into the Wonderful World of Microorganisms" (JIWWM) developed according to the Science–Technology–Environment–Peace–Society (STEPS) approach (Khalil and Lazarowitz 2002).
(4) "A Journey of Inquiry into the Wonderful World of Microorganisms" taught and learned within the Six Mirrors of the Classroom model, in ninth-grade classes: evaluation, results, discussion, and recommendations.

The Six Mirrors of the Classroom Model (SMC)

The model designed to examine the classroom learning procedures, comprises six aspects (mirrors) of the classroom: (1) organization; (2) learning tasks; (3) teacher's instructional behaviors; (4) teacher's communicative behaviors; (5) students' academic performances; and (6) students' social behaviors. Each mirror describes five levels of complexity ranging from simple to complex. For example, in mirror 1, from group class, see the inner ring, which represent class as an entity through dyads, small group low cooperation to small group high cooperation and integration of groups. The teacher may choose to teach in small groups-high cooperation, see mirror 1 and then to go from it, around this ring. (a) Horizontal and vertical division regarding the learning task, see mirror 2; (b) then system facilitator regarding teachers' instruction, see mirror 3; (c) following by group discussion regarding teacher communication, see mirror 4; then (d) multilateral investigation regarding pupil's academic behavior, see mirror 5; and (e) then coordination regarding pupil's social behavior, see mirror 6. Therefore there is a complexity among the mirrors at different levels in each ring, while the teacher can plan his/her instruction by the mirror chosen and then by the complexity among the mirrors in one particular ring.

It is our assumption that by using the SMC, science teachers' instruction can be planed so as, while teaching, the teacher can direct his/her teaching toward achieving higher on the both cognitive and affective domains by a controlled and conceptual process and not being bound only on the "transfer" of knowledge only (Hertz-Lazarowitz 1992). See the SMC in Fig. 1.

The model can serve also as a conceptual framework to guide classroom observation in behavioral categories such as "on-task" and "off-task" behaviors, level of cooperation in the interaction of the students, and helping and social events that take place during the learning. It can be used to train teachers to design their classroom environment and move from traditional whole-classroom instruction to more active and then cooperative learning. The model and its measures assist teachers in testing the effects of cooperative learning on students' academic and social outcomes. The conceptual dynamics among the six mirrors permit the formulation of predictions and the analysis of a range of variables—for example, quality of on-task cooperation as expressed by content, frequency of in-group communication, level of reasoning, and predicted academic and social outcomes.

The SMC as Implemented in the Expository–Frontal and Cooperative Modes of Instruction/Learning in Classrooms and Study's Results

Expository Instruction

The model displayed in Fig. 2 presents the six mirrors in four wings and shows the learning activities that occur in traditional (expository) classrooms. The learning activities are as follows.

Mirror 1. The traditional classroom usually means direct, whole-classroom instruction (also called frontal or expository teaching). One can perceive the physical organization of the traditional classroom as fixed with little or no movement of the students within it.

Mirror 2. The teacher presents the learning tasks to the whole class, and then each student tackles it on his/her own.

Mirrors 3 and 4. The teacher communicates with the class as a whole with a high frequency of lecturing, disciplining, and commenting on negative events in the classroom.

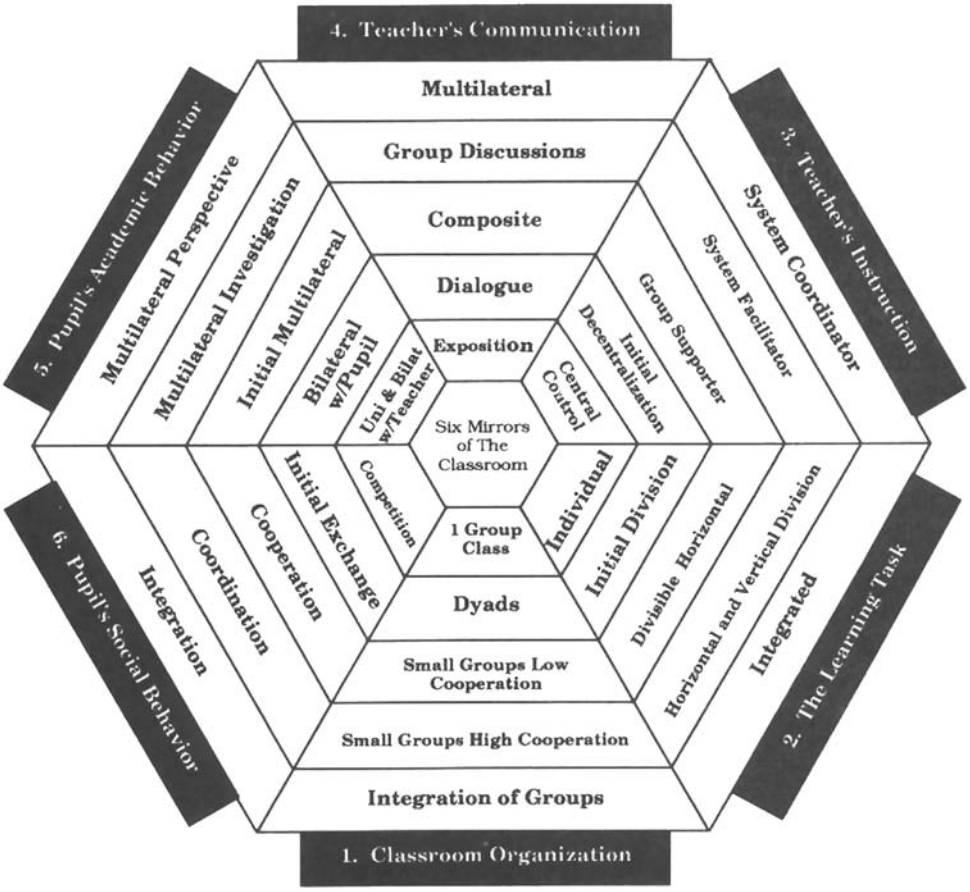


Fig. 1 Six mirrors of the classroom (Hertz-Lazarowitz 1992, p. 74)

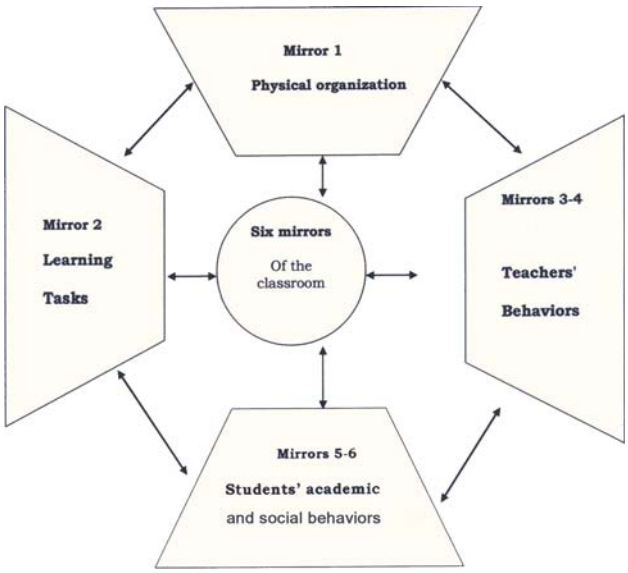


Fig. 2 Four mirrors of the expository classroom (Hertz-Lazarowitz 1992)

Mirrors 5 and 6. Students' behaviors are mostly solitary on-task and off-task activities. Interactive behaviors, which include on-task and off-task and helping activities, occur about 25% of the time. Teachers do not initiate interactions among students and the interactions consist mainly of brief, clandestine types of activities.

Developmental observations showed that from first to twelfth grade, students maintained a stable interactive "on-task behavior" (about 15%), but increased their "off-task" interactive behaviors (Lazarowitz et al. 1988). Teachers considered the increase in social "off-task" interactions to be a negative outcome, indicating increasing discipline problems and disturbances of the teacher's classroom management (Hertz-Lazarowitz 1992).

The SMC in the Cooperative Learning Classroom (See Rings 3 and 4, in All the Mirrors in Fig. 1)

This teaching/learning model was effective in three complex cooperative learning methods: the Jigsaw Method (Aronson et al. 1978); The Group Investigation (Sharan and Hertz-Lazarowitz 1980, 1986); Peer Tutoring in Small Investigative Groups (PTSIG) developed by Lazarowitz and Karsenty (1990).

First, we present short descriptions of the above three cooperative learning methods used in science instruction/teaching in high schools.

Second, we present the implementation of the SMC model in the classroom and the results of its integration into the cooperative learning methods.

The Jigsaw Method (JM) (Aronson et al. 1978)

In the Jigsaw Method, the teacher divides the students into groups of five with the aim of treating one another as resources. The learning goals and materials are structured by the teacher and are divided into five independent sub-units (a, b, c, d and e) that can be learned separately so that the mastery of one sub-unit does not depend on the mastery of any other.

The JM is composed of two cooperative structures. The Jigsaw group (five students who received the five sub-units, a–e) and the expert group (for example, a group consisting of five students from the five Jigsaw groups, all of whom received sub-unit "a", form an expert group; the same applies to a second group whose members all received sub-unit "b", and so on). The students in the expert group learn their part, prepare for peer-tutoring, check each other's mastery of the subject, and return to their original Jigsaw groups to tutor their teammates and prepare together for a test, which includes ten questions, two on each sub-unit. In this method, each student is responsible for teaching his/her part and depends on the other four for their sub-units. One may assume that by learning in this manner, students practice and acquire skills of listening, self-responsibility, mutual dependability and respect, as well as helping behavior. This method employed mostly in elementary schools, includes learning material in the social sciences.

Group Investigation (GI) (Sharan and Hertz-Lazarowitz 1980, 1986)

Group Investigation/GI Group investigation/GI is rooted in Dewey's (1927), philosophy of education and integrates four basic features, investigation, interaction, interpretation and intrinsic motivation. These combined features, form the six mirrors of the GI model:

(1) Students determine sub-topics and organize into research groups; (2) groups plan their investigation; (3) groups carry out their investigation; (4) groups plan their presentations; (5) groups present their topics; (6) teacher and students evaluate their projects. In GI, the investigation process is presented in each stage; groups select topics for investigation according to their interest and curiosity. Thus, in the GI classroom, groups work on different but related topics of investigation. They use a variety of resources to generate questions, gather information, and become active in constructing their knowledge. The teacher is a facilitator, a mentor, and a collaborator in the student's inquiry process.

Peer Tutoring in Small Investigative Groups (PTSIG)

PTSIG, developed by Lazarowitz and Karsenty (1990), is a combination of the Jigsaw Method and Group Investigation. The method was implemented experimentally in high-school biology topics and includes the Jigsaw structure for peer tutoring and the GI structure for the expert counter group, adapted for biology subjects.

The teacher as a curriculum developer designs the biology learning tasks for each sub-unit in an inquiry-investigative sequence of activities. As a result, students work, in their expert groups, on complex and rich learning tasks including long-term laboratory experiments. In their expert groups, students read, make observations on the objects studied, and generate questions for short and long-term investigative laboratory experiments. The tasks include open questions and biological problems solved by students only, by using microscopes, preparing slides, or performing experiments with other group members. After they finish their learning tasks in the expert group, they return to their Jigsaw group for peer tutoring. Usually, the learning sub-units are presented and discussed within their original Jigsaw groups, so all the members will acquire a general knowledge and understanding of the topics. The evaluation is based on students' academic products in their expert groups, and their grades in a test on all the sub-units. The students prepare for the final test with further reading. The teacher occasionally leads the discussion with the whole class to organize and conceptualize important biological concepts. Topics such as cells, animal physiology, photosynthesis in higher plants, and evolution could be divided into five independent sub-units and can be learned by means of a Jigsaw investigative method. Teachers who have implemented PTSGI have developed learning units used in high-school biology classrooms.

The five sub-units can represent different levels of difficulty, thus responding to the heterogeneous nature of the groups. Low achievers can get less demanding sub-units so their expert group will cope with a topic according to their ability. Teachers have to know their students in order to implement PTSGI, so we suggest starting with this method of instruction only after they become acquainted with their students. During the expert groups' sessions, teachers can spend more time with the expert groups that need more attention and stimulation than the other groups, which are more independent in their learning. Thus, this method allows teachers to fulfill their real role as educators by assisting students with different needs in a differential way. In the expository classroom, the teacher teaches the entire class since he/she cannot simultaneously address different students teaching frontally. As a consequence, their instruction is frequently homogeneous in character despite the fact that they are teaching a heterogeneous class. In the cooperative

learning mode, the teacher can address the heterogeneous nature of a classroom by working with the different groups at different times and responding to the specific needs of each group. We call this type of teacher the "floating teacher".

Cooperative Learning and the Six Mirrors of the Classroom

In the three methods described above, students and teachers can practice the complexity of each of the six mirrors as presented in the fifth mirror of the model (Hertz-Lazarowitz 1992, pp. 73–81).

In contrast to traditional classrooms, teachers designed their cooperative learning classrooms so that the physical setting (mirror 1) included 4–5 sub-systems (groups), multiple resources for learning, and considerable movement and contact among the groups. Learning tasks (see mirror 2) were divided horizontally, as in the Jigsaw structure, or vertically and integrated as in the PTSIG or in the GI. In the original Jigsaw Method, students were assigned to groups of 4–6 members, with all members group, who studied the same topic. In each group, each member studies a different section of the topic, and then members from all groups who studied the same section meet in "expert groups" to discuss their part. Student then return to their groups and teach their group members about their section.

In GI, students in the class form groups of 2–6 members. Each group chooses a sub-topic from the general topic assigned to the class and produces a group report. Subsequently, each group shares its findings with the entire class in the form of presentations and class discussions. In Peer Tutoring in Small Investigative Groups especially in biology, the students engage in a more flexible cooperative structure, such as laboratory experiments in addition to GI or Jigsaw. These cooperative learning tasks, which involve peer learning and peer teaching, were designed to increase interdependence and personal as well as collective responsibility.

The pattern of the teacher's communication and instructional behaviors (mirrors 3 and 4) included communication with the whole class for a short period, then with each of the groups as well as with individuals who required assistance. The teacher observed a given group and helped advance its discussion to a higher level. Most of the time, the teachers helped, explained, and gave feedback to the students. Little disciplining took place and only a few negative comments were heard in the classroom. In this context, students engaged quite frequently in interactive, cooperative, and helping behaviors and in lively and stimulating group discussions, resulting in a high cognitive level of peer learning. Mirror 6 displays the level of cooperation and the skills used.

These descriptions of class activities and dynamics exemplify how the "anatomy of cooperation" model of the six mirrors facilitated the observation and investigation of academic outcomes.

The positive academic and social outcomes of cooperative learning were presented in many writings (Gillies and Ashman 2003; Hertz-Lazarowitz 1992, 2008; Hertz-Lazarowitz and Zelniker 1995; Johnson, Johnson and Stanne 2000; Lazarowitz 1995a, b; Lazarowitz 2006; Lazarowitz and Hertz-Lazarowitz 1998; Lazarowitz and Karsenty 1990; Slavin 1995; Slavin, Hurley and Chamberlain 2003).

"A Journey of Inquiry into the Wonderful World of Microorganisms"

A Journey of Inquiry into the Wonderful World of Microorganisms developed according to the Science–Technology–Environment–Peace–Society (STEPS) approach (Khalil and Lazarowitz 2002).

Following the general description of the SMC model, we present a learning unit, "A Journey of Inquiry into the Wonderful World of Microorganisms" (Khalil (2002a, b), for the middle-school level, which includes two manuals: the Student's Manual and the Teacher's Guide. The author wrote the textbooks using a Science–Technology–Society (STS) approach, and added the concepts of environment and peace, thereby broadening the goals of instruction and learning to Science–Technology–Environment–Peace–Society (STEPS). The textbooks, written in the Arabic and Hebrew languages for ninth-grade students (middle school), could be used by students and teachers in the Arab and Jewish schools. In this study, we hypothesized that the subject matter, which emphasizes environmental issues and preservation, will improve students' attitudes toward the environment and furthermore, when students learn about and collaborate on environmental topics in cooperative groups, it will have an impact on their attitudes toward peace, too.

The learning unit encompassed two main biological principles: the principle of the unity of life in the world and the principle of the structure and function relationship. The problems raised in the unit concerned health issues, the environment, microorganisms, and drainage canalization between neighboring villages or countries. This unit enabled us to investigate achievement in the academic cognitive domain as well as in the affective domain, attitudes toward environmental preservation, and understanding and peace among people who live in close proximity.

The following topics were included in the learning unit: microorganisms and their structure, physiological processes, the role of microorganisms in the food chain, carbon and nitrogen cycles, the food industry, the environment, and the level of health in society. The unit helped students master practical skills in laboratory work and develop scientific thinking and problem-solving skills. The learning tasks included individual and small-group instructional settings,

utilizing a variety of teaching and learning methods in the classroom and the laboratory work. Students read scientific essays, watched videos, played group games, went on group trips in nature, visited food industries, and searched for information from various sources, including the Internet and libraries. The learning unit raised students' motivation by being practical, connected with daily life, and involved in societal issues. In this manner, the relationships among science, technology, environment, and society were emphasized.

"A Journey of Inquiry into the Wonderful World of Microorganisms" and the Six Mirrors of the Classroom Model in Ninth-Grade Classes

In this paper, we will present the implementation of the learning unit in the Arab school in the frame of the SMC model and only two learning task will be depicted in relation to the mirrors used.

The learning unit (JIWWM) comprised 15 sub-units. In Table 1, we present the descriptions of sub-units 1 and 2 as presented in Khalil and Lazarowitz (2002), and we analyze the learning activities according to the six mirrors of the classroom model. In order to encompass the analysis and understand it, the reader should follow Fig. 1, the SMC model, and Table 1.

Sub-Unit 1 Sub-unit 1 is an introduction to the study of the microorganism. Table 1 presents:

(a) study objectives; (b) science content knowledge; (c) technological aspects; (d) societal aspects; and (e) pedagogical content knowledge.

The six mirrors of the classroom are as follows:

Physical Classroom Organization (mirror 1) reflects the teacher's perception of the students as a "one-group class" ready for the teacher's presentation.

Learning Task Structure (mirror 2) included two tasks—the first is a classroom discussion on old concepts of microorganisms, and the second was a summary written by each student reflecting on his/her new learning. Both tasks were unitary, that is, every student must individually complete the same task in its entirety.

Teacher Instruction Behaviors (mirror 3) indicates that the teacher controls the discussion with the students as well as their reflective summary.

Teachers' Communication (mirror 4) is expository–unilateral (teacher–student) when the teacher lectures to the students, and dialogue–bilateral when the teacher is involved in questioning, answering, and clarifying students' input in the discussion.

Students' Academic Behavior (mirror 5) is unilateral and bilateral interaction with the teacher, when the students are academically engaged in the science knowledge content related to the learning tasks presented to them by the teacher.

Students' Social Behaviors (mirror 6) is mostly competition because the students compete for the teacher's attention and for the privilege of being among those who will answer the teacher's questions. There is a chance for initial exchange if the teacher encourages the students to share the summaries/portfolio with him and among them (Hertz-Lazarowitz 2008, pp. 47–48).

Sub-Unit 2 Sub-unit 2 deals with "The Garden of the Microorganism". According to Table 1, we find that the science content knowledge (b) is highly diverse. Students

Table 1 Study objectives, science content knowledge, technological aspects, societal aspects and pedagogical content knowledge of the two learning sub-units

Sub-unit	(a) Study objectives	(b) Science content knowledge	(c) Technological aspects	(d) Societal aspects	(e) Pedagogical content knowledge
1	Introduction to the study of microorganisms	Definition of microorganisms Classification of organisms Characteristics of microorganisms	Using the microscope in the laboratory work to observe bacteria	Micro-organisms and diseases Their role in science research Plants, roots, bacteria and N cycles	Classroom discussion on old concepts regarding microorganisms role in food industry. Conceptual change
2	"Garden" of microorganisms	Microorganism's main features and diversity Bacteria, isolation seeding Aerobic and anaerobic microorganisms Seeding and growth of microorganisms on Petri dishes	Techniques for "gram" dyeing Sterile methods in the laboratory work Using the video scope	Symbiosis between bacteria and plants on nitrogen binding as a model of cooperation. Bacteria and human digestive system: hygiene, health and diseases.	Group experimenting Processing and presenting information Presenting the findings Group summary Conducting observations Class discussion

have to master many technological aspects (c) and acquire rich pedagogical content knowledge (e).

Physical Classroom Organization (mirror 1) small groups with low or high level of cooperation. Each group is composed of 4–5 students. The leading cooperative learning method is the PTSIG.

Learning Tasks Structure (mirror 2) include several tasks based on division of work in complex structures: horizontal—different elements assigned to different students; vertical—those elements have to be combined and integrated so that all information is included to form a cohesive whole, such as in the Garden of the microorganism (Hertz-Lazarowitz 2008, pp. 49–51).

Teacher' Instruction (mirror 3) indicates a highly complex structure. First, is a unit that requires a sequence of several weeks' instruction. The teacher will therefore have to demonstrate all five levels of instruction presented in this mirror, including when "central control" and "initial decentralization" are necessary. However, most of the instruction will deal with groups and the system. Second, he/she will have to give a lot of "group support" when discussions and decision-making are distributed among the students in the groups. Third, the teacher will be a "system facilitator" for students' learning and interaction while conducting the experiments and the many other tasks. Fourth, his/her role and behavior as a "system coordinator" reflected in meeting deadlines and in coordinating tasks and activities. The teacher is truly "the guide on the side and not the sage on the stage".

Teacher Communication Behaviors (mirror 4) include the five levels as presented in Fig. 1. Teacher communication networks range from expository–unilateral lectures to bilateral and multilateral systems on several levels: teacher communication with individuals and small groups, and the facilitation of communication among groups. In the most complex pattern, the teacher focuses on encouraging communication by facilitating planning and investigation, thereby utilizing composite, coordinated, and multilateral integrated networks of communication.

Students' Academic and Social Behaviors (mirrors 5 and 6). The two mirrors of students' social and academic behavior are closely interrelated in the context of the classroom. Academic skills range from simple and passive such as listening or interacting with the text unilaterally and bilaterally to highly creative and evaluative skills that are required in order to conduct and analyze the results of the experiments, to analyze microscope-based observations, and to cooperate in a scholarly oral presentation and the written product.

Students' Social Behaviors (mirror 6). Academic and social behaviors in this context are cognitively and socially more complex than in the context described in sub-unit 1. While the sub-unit also includes individual work, it aims to create forms of cooperative academic–social integration of knowledge, sharing, and helping by means of the exchange of ideas and information. The students assume social–academic roles such as leadership and mentoring, and the personal and group thinking is directed at producing a higher-level final product based on the individual accountability of every student, each of whom is striving to meet all of the detailed objectives for the sub-unit.

We hypothesized that students would develop positive attitudes and the ability to judge objectively the problems associated with environmental preservation, while understanding the important role of microorganisms in the life web life. The outcomes on the cognitive and affective domains were obtained by analyzing the portfolios compiled by the students while studying in the classroom, in the laboratory work, and while doing their homework. The results show that students improved their academic achievement, developed positive attitudes toward the environment, and understood the role of the people's concerns regarding the preservation of nature and its relation to peace (Khalil and Lazarowitz 2002).

Teaching/Learning the JIWWM, in Ninth-Grade Classes: Evaluation, Results, Discussion, and Recommendations

Following the depicted section of how the two sub-units 1 and 2, out of the 15 sub-units, of the learning unit, "Microorganisms" were integrated within the SMC model, we present a short research report on the study.

The learning unit implemented in the middle school permitted an evaluation of the students on the cognitive and affective domains.

The sample included 91 students, of them 73 (80.2%) from 9th grade classes: 34 students (37.4%) were from village "B", 39 students (42.9%) were from village "A" and 18 students (19.8%) were from a class for gifted students. The sample included 46 girls and 54 boys. In village "B" 53% were boys and 47% were girls and in village "A" 61% were boys and 39% were girls.

The two schools that participated in this research were government schools; both classes were heterogeneous from the point of view of their learning achievements.

Prior Knowledge

None of the students had previously studied the subject of microorganisms.

Teachers

The teacher in village "A" held a master's degree in biology, and served as a mentor to other teachers. He received

guidance in a special workshop, which introduced him to the mode of instruction and evaluation used in STS approach, including the subject of student portfolios. The students from village "B" and that of the gifted children were taught by the teacher who carried out this research project.

The Microorganisms Learning Unit Included the Following Sub-Units Topics

1. Introduction to the study of microorganisms
2. "Garden" of microorganisms
3. Microorganisms in food and drinks industries
4. The contest of "What tastes better?"
5. Bacteria in the service of the human being
6. The story of a food processing plant
7. A visit to a "healthy fruit" food plant
8. Plants, sewers and pollution
9. Why do birth givers die?
10. Antibiotic test for preventing and end life of bacteria
11. Diseases caused by microorganisms
12. The importance of microorganisms in the elements cycles
13. Genetic engineering—the two sides of a coin
14. Microorganisms in data pools
15. Antibiotics or Probiotics

Three learning tasks from the learning unit, (sub-units 4, 5 and 6) which include the content knowledge, societal aspects and pedagogical content knowledge and have a strong relation to the environment and peace topics, are presented as follow. These examples illustrate the sub-units learning tasks as were introduced in the Teacher Guide Book (Khalil 2002b). See sub-units 4, 5 and 6 in Table 2.

Hypotheses

(a) Learning about microorganisms and their impact on technology and societal issues will have an impact on students' cognitive achievement.

(b) Learning tasks, which promote collaboration through cooperative learning settings, will have an impact on students' attitudes toward environment and peace.

Table 2 Sub-units 4, 5 and 6: study subjects, science content knowledge, technological aspects, societal aspects and pedagogical content knowledge

Sub-unit	Study subjects	Science content knowledge	Technological aspects	Societal aspects	Pedagogical content knowledge
4	The contest of "What tastes better?"	The biology of food products' preparation Important terms and processes in food producing by microorganisms	Means for checking variables: temperature, pH Technological methods for improving the production of food products in the industry	Economic aspects Relations among neighbors and solving environmental issues in peaceful means Cooperation and mutual aiding among neighbor countries for the purpose of improving economy and farming	Conducting an experiment and team work Critical thinking Systematic perception Graphic presentation Identifying problems and suggesting hypotheses Class discussion Inferring and conclusions
5	Bacteria in the service of the human being	Microorganisms in the food industry	Chemo stat Technological limitation in the food industry	Technologies and food to poor countries	Systematical use of the video tape films Logical thinking Asking questions Inferring and conclusions
6	The story of a food processing plant	Food preservation Food spoiling by microorganisms	Food preservation techniques: sterilization, pasteurizing, freezing, drying, etc.	Wise and proper consuming and man's health Marketing deadline Environment quality, pollution and fish poisoning of a lake The location of a food factory plant Social and economical profits from food plants	Critical reading of a scientific article Critical and logical thinking Deduct ional and concluding process Defining problems and suggesting solutions

Research Design

The research design was based on Quasi-Experimental Design (Campbell and Stanley 1963). Three questionnaires, students' achievements, on attitudes toward environment preservation and toward peace, are depicted as follow.

Instruments

Classroom Observation Map. (Cognitive and Meta-Cognitive Knowledge)

In this study the impact of the learning unit taught within the frame of the SMC, on students' cognitive achievements, was investigated by using the Classroom Observation Miror (COM) developed by Acheson and Gall (1980). This instrument examines the interaction occurred between the student and the teacher during the lesson. The page includes rectangles, in which the students' seats appear. An X marks missing students. During the visit in the class the observer marks any question posed by the teacher to any student, and students' questions to the teacher. The cognitive level of the questions asked by the teacher or the students are classified according to Bloom (1956) taxonomy, one point for the knowledge, low cognitive level, to six points for the evaluation level, the higher one. In their study, Anton, Lazarowitz and Hofstein (1994), validated the COM for its translation into the Arabic language and for its use with Arab High School students.

See the COM in Appendix 1.

Procedure

The visits occurred three times in study class A. Observation 1, took place, two weeks before the study started, while the students learned the nutrition subject (saturated and unsaturated fats and cholesterol) in an expository mode. Observations 2 and 3 were carried out at the beginning of the study when students learned the micro-organisms unit within the frame of the SMC, task 3, food and drinks in the industry and at the end of the study, task 13, genetic engineering, the two sides of a coin. The two tasks were preferred since in both of them the same mode of instruction was used, reading a part of a scientific paper on the subjects mentioned above and an interactive classroom discussion occurred among the teacher and the students while their questions were noted and evaluated. All the observations and the questions asked were validated by the researcher, who met students and the teacher following the lesson in order to make sure that his observations and their evaluation occurred and fit the cognitive levels of the Bloom taxonomy. This triangulation process of the data provided the validation for the instrument.

Questionnaire for Assessing Attitudes Towards the Environment

The questionnaire "Children's Environmental Attitude and Knowledge Scale" (CHEAKS) was developed by Leeming et al. (1995).

The original questionnaire included two sections: one examined the attitudes towards the quality of the environment and the readiness to preserve the environment and the second section assessed the knowledge on the subject of the quality of the environment.

In this study, the first section on attitudes which included 36 items was adopted. The questionnaire was adjusted and validated, for ninth grade classes in the Arab sector.

The questionnaire in its new form was examined for the scientific, pedagogical and educational content validity by a science educator. Then the questionnaire was translated into Arabic by the investigator. This translation was validated by the use of Reverse Translation Method. The questionnaire was given to a teacher who was an expert in both languages (teaches in both Hebrew and Arabic). She translated the questionnaire back to the Hebrew language and then a comparison was carried as to its relativity to the original reverse translation. Non-relative items which emerged were rephrased in a discussion meeting between the teacher and the researcher.

In the last step, two experienced teachers from the Arab sector validated the questionnaire for its scientific and educational content for the Arab students. Both teachers hold M.Sc. degrees, one in biology and one in science education.

Scoring Procedure

The weight of each item was scored on the LIKERT scale: from 1 to 5: entirely not correct = 1, not correct = 2; not sure = 3; correct = 4; very correct = 5. Since the items 12, 14–22 and 25–27, were formulated in a negative manner, they rated from 5 to 1. Students answered the questionnaire at the beginning of learning the unit, and at the end of the study. See the questionnaire in Appendix 2.

The Questionnaire for Assessing Attitudes Toward Peace

The original questionnaire investigating attitudes toward peace was developed by Pasternack and Tzedkiyahu (1994). The items referred to the degree of belief in peace, the price willing to pay for peace, education towards peace in the school, and the role school can play in educating toward peace. The questionnaire includes 15 questions.

Table 3 The reliability values for the questionnaires on attitudes toward environment and peace

Research questionnaires	No. of items	Assessments	Scores range	(*N*) Students	Alpha Cronbach values
Attitudes toward environment	16	Pre	1–5	71	.79
		Post	1–5	68	.73
Attitudes toward peace	9	Pre	1–5	85	.62
		Post	1–5	82	.72

In this study, the questionnaire was validated and adjusted for the use in ninth grade classes in the Arab sector. Only items relevant to the Arab sector were chosen. For example, an item which enquired "as to whether education towards peace may prejudice the willingness of adolescents to join the army" was not selected. Items which were considered suitable for the Arab students were adapted in consultation with the original developers: (for example: item 7 "Is it possible that education towards peace might affect one's Jewish identity?" was changed to: "Is it possible that education towards peace might affect Palestinian identity?"

In summation, 9 of the 15 items were selected. Students' answers were scored using the LIKERT scale: full agreement = 5 to complete disagreement = 1, on the positive items, while the items 1–5, 9 and 10 which were negatively phrased were scaled: full agreement = 1 to complete disagreement = 5 (see Appendix 3).

The reliabilities of the questionnaires were assessed by Alpha–Cronbach Test with the study sample. The number of items and the Alpha–Cronbach values for the two questionnaires pre and post are displayed in Table 3.

Results

Cognitive and Meta-Cognitive Knowledge

The frequency and percents of teacher and students' questions are presented in Table 4.

Observation 1. Teacher asked 8 questions and students 3 questions only on the nutrition topic taught on the expository mode. All the questions were on the low cognitive levels, knowledge and comprehension. Observations 2 and 3 show a different picture while the microorganisms unit was taught within the frame of SMC, at the beginning and end of the study. The teacher asked 14 and 12, spread on the low and high cognitive levels. Students show a similar picture, an increase to 9 and 13 questions spread on the low and high cognitive levels while their number on the high level increased on the Observation 3 compared with the Observation 2.

Therefore the main findings show a significant and improvement of the cognitive and meta-cognitive knowledge of the students, asking questions mostly on the higher cognitive levels, application analysis and evaluation.

Table 4 Frequencies and percents of teachers' and students' questions and their level according to Bloom's taxonomy

Kind of behavior observed	Question category (according to Bloom)	The subject of "Fats", in the book: "Chapters in nutrition"		"Microorganisms" learning unit			
		Observation 1		Observation 2		Observation 3	
		N	%	*N*	%	*N*	%
Questions by the teacher	Knowledge	5	62.5	6	43	4	33.3
	Comprehension	3	37.5	3	21	3	25
	Application	0	0	1	7	1	8.3
	Analysis	0	0	2	14	1	8.3
	Synthesis	0	0	0	0	0	0
	Evaluation	0	0	2	14	3	25
	Total	8	100	14	100	12	100
Questions by the students	Knowledge	2	66.6	5	55.6	5	38.4
	Comprehension	1	33.3	2	22	3	23
	Application	0	0	1	11	2	15.4
	Analysis	0	0	1	11	2	15.4
	Synthesis	0	0	0	0	1	7.7
	Evaluation	0	0	0	0	0	0
	Total	3	100	9	100	13	100

Comparing the results displayed on Table 4, one can see that the integration of the microorganisms subjects with environment and peace as societal issues, which are the components of the STS approach, and taught within the SMC model, facilitated teachers and students to ask more questions and at a higher cognitive level then learning regular subjects in a expository mode.

Attitudes Toward the Environment

The mean scores of the students on attitudes toward the environment were analyzed by the use of the *t*-test and ANOVA. The mean scores, standard deviations, *t*-test and two way ANOVA values are displayed in Table 5.

The results show that the students in village "B" showed positive and significant increase in their attitudes towards the preservation of the environment after studying the learning unit. There was a small increase in the mean scores on the attitudes of students in village "A" and in the class of the gifted students, but the differences were not significant.

Attitudes Toward Peace

The mean scores on the attitudes of the students toward peace were analyzed by the use of the *t*-test and ANOVA. The mean scores, standard deviations, *t*-test and two way ANOVA values are shown in Table 5.

The results show a significant improvement in the attitudes of the students towards peace among the students in village "A" only. No improvement on attitudes towards peace occurred in the class in village "B". However, the students in the gifted class were significantly positive in their attitudes towards peace.

It seems to be that studying the learning unit in the STS mode within the SMC model, affected the students in their attitudes towards peace, particularly in that they agreed that the educational system can affect the attitudes of students both in their comprehension of ideas, and the stereotypes that they held although the differences were not significant always.

Discussion

Higher cognitive and cognitive achievements (asking questions) can be explained by

(a) The diversity of the teaching procedures during the lessons.

The students were able to "wander" through the various tasks that they were asked to complete, which on the whole, were active and the center of the learning activities; they were held responsible for learning the material as they progressed from task to task. Among the activities found most favorable were the laboratory experiments, the field trips, the movies exhibited, and the use of cooperative and small groups for learning specific tasks.

(b) Diversity in Content

This factor contributed in all learning tasks and lessons, adding new learning experience. For instance, a student that finds no interest or understanding in one task could freely choose a task in accordance with his/her inclination and interest. The results of this approach, as many parents noted in surprise, was that their students began to interest themselves in the library—dusting off books, and spending long hours by delving into the various subjects that came up in class.

(c) The connection between the learning content as are presented in the science, technology and societal

Table 5 Mean scores, standard deviations, *t*-tests and two-way ANOVA by study groups on (a) attitudes toward environment and (b) attitudes toward peace

Study Group	Pre		Post		*t*
	X	(SD)	X	(SD)	
Attitudes toward environment					
Regular class "B"	3.76	(.54)	4.02	(.43)	−3.26**
Regular class "A"	3.98	(.80)	4.15	(.55)	−1.41
Gifted class	4.10	(.51)	4.34	(.20)	−1.88
F	1.73		2.91		$F = 1.77$
Attitudes toward peace					
Regular class "B"	3.76	(.57)	3.67	(.66)	.17
Regular class "A"	3.83	(.62)	4.13	(.54)	−3.02**
Gifted class	4.20	(.21)	4.28	(.26)	−1.16
F	4.10*		9.15***		$F = 5.30$**
Scheffe	"B"-gifted		"B"–"A", gifted		

* $p < .05$
** $p < .01$
*** $p < .001$

issues as environment preservation and peace, and the daily life of the students.

This connection makes it possible for the students to grasp this approach, not only as interesting, but important as well. The students understood the importance of the study unit on a personal level, as well as on a social level. This enabled the increase of their motivation to learn, and as such raised their learning achievements as well; as their achievements rose, so did their motivation increase. This is comparable to the definition of pleasure given by Johnson and Johnson (1985) as the level of investment of the student increases, in his/her desire to improve their learning achievements, particularly in the fields that are significant and worth while for them, they find more pleasure in learning.

Attitudes Towards the Quality of the Environment and Peace

The aims of the learning unit on microorganisms were centered on the desire to foster positive attitudes on the part of the students in relation to the quality of the environment and toward peace. We can understand the improvement on attitudes towards the quality of the environment and peace, as the result of diversified learning experiences in a number of subjects, open questions asked during the carrying out of various learning tasks, discussions in the class on questions and subject concerning the quality of the environment and peace, encouraging open and personal learning activities. All these factors were included in the portfolios that the students kept, This meant concentrating on the tasks carried out, writing essays, holding interviews, and commenting on the research they did into information on various subjects that they themselves compiled. One may conclude that the progress that students made on the subjects of the quality of the environment and peace, were primarily influenced by two factors: the use of relative content, and the diverse methods of teaching and learning facilitated by the SMC model.

Environment

In relation to the quality of the environment, many of the research projects carried out on this subject, cited a positive change on the issue, citing the importance of integrating environmental aspects in the learning units (Dori and Hershkovitz 1999; Tal 2005). In these research results, it appears that after completing the study of the learning unit, there was an improvement on the students' attitudes in relation to personal responsibility, more active participation, and the initiation of projects that were connected to the environment. The explanation can be found in the content of the learning unit that combined subjects dealing with the environment, with the teaching/learning methods practiced in this study. This is particularly true with the emphasis on class discussions, learning trips, and television programs. The use of alternative assessment approaches, made it possible to identify the means by which students can become more creative and open to new ideas.

Peace

This research may be considered to be a pilot project in the domain of attitudes towards peace. This is the first research project carried in Israel that investigated the influence of a learning unit, combined with student attitudes towards peace, as a societal issue, integrated with subjects in science, technology and the environment. The results received, show a positive change in students' attitudes towards peace. This constitutes a challenge to the educational system, which should accept this task at this particularly difficult time, more than at any other time in the past.

According to Pasternack and Tzedkiyahu (1994) educators should consider one of the major tasks of the school is to educate towards peace. In essence, the school is the only institution that all adolescents pass through, that is in a position to influence the formation of important attitudes.

A change in students' attitudes is possible if sensitive subjects are taught in a manner, which is suitable to them (Koballa 1989). The process of change in students' attitudes does not necessarily require a great deal of time and can be measured in weeks or months. An instance of this was the time required to teach the unit on microorganisms (36 h).

The recognition as to the importance of involving the students in the actuality of peace issues, whether they are immediate, or long running, should not be left out of the curriculum, in both the Jewish and Arab schools (Pappa 1999).

The important skills activated in this learning unit and emphasized were: attentiveness, the development of weighing options, the solution of conflicting items, the ability to explain and give reasons for one's ideas, the ability to bridge and link differences, non-violent communication and the acceptance of variance and multiculturist.

The results of this research project points out the necessity of encouraging the development of learning units which integrate the subjects of peace, with science and technology. This requires the education of teachers and curricula developers towards this approach, with an emphasis on teaching strategies, varied and relevant means

of evaluation. The aim of this kind f approach is to inculcate the principles of equality, the acceptance of others with mutual respect, tolerance, attentiveness and the ability to express oneself—all of the above aims lead to good citizenship.

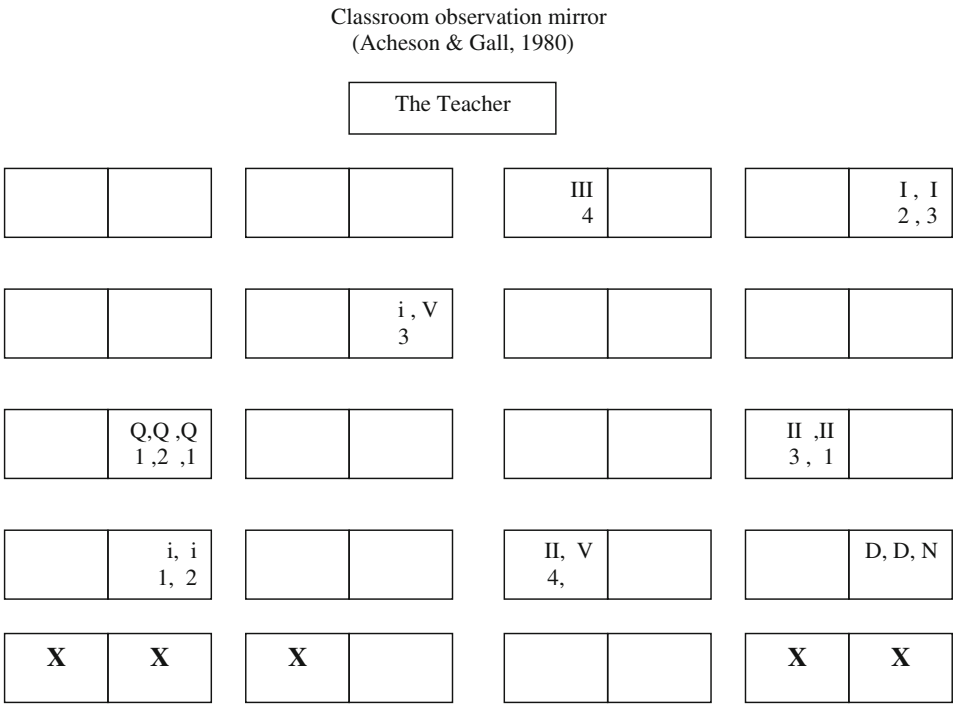
In this study it was found that integration of environment and peace topics in the learning unit can have an impact on students' positive attitudes. Therefore, the concept of STS can be enlarged by adding the letters of "E" and "P", so science, society, technology, environment and peace will result in STEPS.

Summary

No studies were found in science education whereby learning tasks taught and learned using the dimensions of the six mirrors of the classroom (SMC) model were evaluated systematically. This study is a pioneer trial and it is reasonable to assume that many aspects of the learning tasks were ignored. Nevertheless, the results show that cooperative skills were practiced, academic outcomes were achieved, and attitudes toward environmental preservation and peace improved when the learning process was carried within the SMC model. Future studies should identify more learning activities included in science learning tasks related to expository and cooperative instructions within the dimensions in every mirror of the model. More dimensions may be found, enriching the mirrors' levels with more details related to the teaching/learning science processes. The SMC model can then serve as a valuable tool for teachers, since it can design their teaching and learning settings in a more controlled priority environment, in terms of objectives, teacher's and students' social behaviors, and academic outcomes.

The SMC model facilitates the development of a theory of instruction in the classroom by providing a framework in which the various dimensions' levels of it, can be conceptualized and where the learning tasks can be design and related to the different dimensions in the six mirrors.

Appendix 1



Observation During the Lesson

1. Mark X on the seats of missing students, then write the number of the students in the class …35…
2. During the lesson the observer writes the interactions which occur in the class:

   I—the student answers a teacher question without permission.
   II—the student answers a teacher question with permission.
   III—the student answers a teacher question posed to him/her.
   I—the student did not answer or his/her answer is wrong.
   Q—the student asks the teacher a relevant question to the subject learned.
   V—the teacher encourages the student to ask.
   N—the teacher rebukes on student.
   D—the student disturbs the learning process.
   O—the student is asked to leave the class.

3. The cognitive level of the teacher question (Bloom, 1956).
4. The cognitive level of the student question (Bloom, 1956):
   1. Knowledge, 2. comprehension, 3. application, 4. analysis, 5. syntheses, 6. evaluation

Appendix 2—Questionnaire on Attitudes Toward Environment

Dear students: We will be very grateful to you for answering the following questionnaire. Thank you very much:

Name: _____ Class: _____
School: _____ Date: _____

The following items relate to the "Microorganisms" learning unit. Please read each item and mark + in the appropriate place, which reflects your evaluation

	Item	Strongly agree	Mildly agree	Mildly disagree	Strongly disagree
1	I would be willing to stop buying some products to save animals' lives				
2	I would not give $15 of my own money to help preserve the environment				
3	I have talked with my parents about how to help with environmental problems				
4	I have asked others what I can do to help reduce pollution				
5	I have written someone about a pollution problem				
6	I do not let a water faucet run when it is not necessary				
7	I am frightened to think people do not care about the environment				
8	I get angry about the damage pollution does to the environment				
9	It makes me happy when people recycle used bottles, cans and paper				
10	I get angry when I think about companies testing products on animals				
11	It makes me happy to see people trying to save energy				
12	I am not worried about running out of water				
13	I do not worry about environmental problems				
14	I get upset when I think of the things people throw away that could be recycled				
15	It frightens me to think of how much energy is wasted				
16	It upsets me when I see people use too much water				

Table a continued

Appendix 3—Questionnaire on Attitudes Toward Peace

Dear students: We will be very grateful to you for answering the following questionnaire. Thank you very much:

Name: _____ Class: _____ School: _____ Date: _____

Please cycle the item a, b, c d or e that reflects your stand. You can choose only one letter for each question.

1. Do you believe there will be peace between Israel and Palestinians in the near future?
   a. I absolutely believe
   b. I believe
   c. I am not sure
   d. I do not believe
   e. I absolutely do not believe
2. Are you pro or against the principle: peace for land?
   a. I strongly agree
   b. I agree
   c. I am not sure
   d. I disagree
   e. I strongly disagree
3. Is the education system able to influence the youth attitudes toward different issues related to the political process?
   a. Of course it could
   b. It could
   c. I am not sure it could
   d. It could not
   e. Of course it could not
4. Is it the Education system responsibility to change the youth perception of the Jewish as an enemy?
   a. Of course yes
   b. Yes
   c. I am not sure
   d. No
   e. Of course not
5. Is it the Education system responsibility to change negative stereotypes about the Jewish people?
   a. Of course, yes
   b. Yes
   c. I am not sure
   d. No
   e. Of course not
6. There are those who claim that it is not the education system's responsibility to deal with education for peace. Do you agree with this statement?
   a. I strongly agree
   b. I agree
   c. I am not sure
   d. I disagree
   e. I strongly disagree
7. Will the education for peace hurt the Palestinian identity?
   a. Very sure
   b. Sure
   c. Not a lot
   d. A little
   e. Absolutely not
8. Do you approve the meetings with the Jewish youth as a part of your studies in the school?
   a. I will absolutely agree
   b. I will agree
   c. I am not sure
   d. I will not agree
   e. I absolutely will not agree
9. Are you interested with the issue of education for peace?
   a. I am very interested
   b. I am interested
   c. I am not sure it is interesting me
   d. I am not interested
   e. It does not interesting me at all

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