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Failing the Test or the Failure of the Test: The Case of Environmental Education in Israel

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Abstract: Different approaches are employed when teaching environmental issues. One approach, termed the "environmental scientific approach," perceives environmental education as part of life or earth sciences, providing factual, scientific knowledge. Another approach, termed the "environmental sustainability citizenry approach", emphasizes sustainability and balancing between the need to move forward technologically and economically and the need to protect the environments in which we and others live. A synthesis of the two approaches encompasses both environmental scientific literacy and environmental sustainability citizenry. This article examines the degree to which changes in the emphasis given to the two approaches worldwide and in Israel impacted the achievements of Israeli eighth graders in this field. Based primarily on data from the Third Mathematics and Science Study-(TIMSS), the findings indicate that the TIMSS tests were biased toward the "environmental scientific" approach, in contrast to the more recent

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and accepted trends of the "environmental sustainability citizenry approach" embedded in Israeli curriculum. The assessment of environmental achievements in Israel, that was based on the biased test of the TIMSS study, fails to accurately reflect both the curricular changes that have taken place in Israel in this field and students' achievements, thus rendering this assessment inappropriate for this purpose.
Key words: TIMSS; environmental education; student achievement; Israel

Reprobar la prueba o el fracaso de la prueba: El caso de la educación ambiental en Israel
Resumen: Se utilizan diferentes enfoques para enseñar temas ambientales. En un "enfoque científico ambiental", la educación ambiental se considera parte de las ciencias de la vida o de la tierra, que proporciona conocimientos científicos basados en hechos. Un "enfoque ciudadano de sostenibilidad ambiental" enfatiza la sostenibilidad y el equilibrio entre la necesidad de avanzar tecnológica y económicamente. La síntesis de los dos enfoques abarca tanto la alfabetización científica ambiental como la ciudadanía de sostenibilidad ambiental. Este artículo examina el grado en que los cambios en el énfasis dado a los dos enfoques en todo el mundo y en Israel afectaron los logros de los estudiantes de octavo grado israelíes en este campo. Basado principalmente en datos del Tercer Estudio de Matemáticas y Ciencias (TIMSS), los hallazgos indican que las pruebas TIMSS estaban sesgadas hacia el enfoque "científico ambiental", en contraste con las tendencias más recientes y aceptadas del "enfoque de ciudadanía de sostenibilidad ambiental" integrado en el plan de estudios israelí. La evaluación de los logros ambientales en Israel, basada en la prueba sesgada del estudio TIMSS, no refleja con precisión tanto los cambios curriculares que han tenido lugar en Israel en este campo como los logros de los estudiantes, por lo que esta evaluación es inapropiada para este propósito.
Palabras clave: TIMSS; educación ambiental; logro estudiantil; Israel

Para reprovar no teste ou reprovação no teste: O caso da educação ambiental em Israel
Resumo: Diferentes abordagens são usadas para ensinar questões ambientais. Em uma "abordagem científica ambiental", a educação ambiental é vista como parte das ciências da vida ou da terra, fornecendo conhecimento factual e científico. Uma "abordagem cidadã de sustentabilidade ambiental" enfatiza a sustentabilidade e o equilíbrio entre a necessidade de avançar tecnológica e economicamente e a necessidade de proteger o meio ambiente. Uma síntese das duas abordagens abrange tanto a alfabetização científica ambiental quanto a cidadania para a sustentabilidade ambiental. Este artigo examina o grau em que as mudanças na ênfase dada às duas abordagens em todo o mundo e em Israel impactaram as realizações dos alunos israelenses da oitava série neste campo. Com base principalmente em dados do Terceiro Estudo de Matemática e Ciências (TIMSS), os resultados indicam que os testes TIMSS foram tendenciosos para a abordagem "científica ambiental", em contraste com as tendências mais recentes e aceitas da "abordagem cidadã de sustentabilidade ambiental" incorporado no currículo israelense. A avaliação das realizações ambientais em Israel, que foi baseada no teste tendencioso do estudo TIMSS, falha em refletir com precisão as mudanças curriculares que ocorreram em Israel neste campo e as realizações dos alunos, tornando esta avaliação inadequada para este propósito.
Palavras-chave: TIMSS; educação ambiental; conquista do estudante; Israel

Failing the Test or the Failure of the Test: The Case of Environmental Education in Israel

Over the past 50 years, public awareness of environmental problems has increased. As a result, in many countries environmental issues have begun to occupy a greater place in school curricula (Benavot, 2004). This trend was supported also by the highly publicized, comparative studies of educational achievement conducted by the International Association for the Evaluation of Educational Achievement - IEA (e.g., TIMSS-Third International Mathematics and Science Study and CIVED-Civic Education Study and ICCS-International Civic and Citizenship Study), as well as by the OECD (e.g., PISA-Programme for International Student Assessment) and UNESCO. As a result of these studies, renewed academic interest and public debate over curricular contents have been generated. The influence of these global international organizations in legitimizing contents and curricular models grew, while the predominance of the nation-state school curricula decreased (Benavot & Amadio, 2005; Bromley et al., 2011; Meyer Bromley & Ramirez, 2010; Ramirez & Meyer, 2012).

Meyer and Ramirez (2010) call this "post national" curricular changes, stressing more global, cultural interests such as human rights, citizenship, and diversity. As part of this global change several 'newer' subjects became more prominent in the school curriculum. Amongst them, environmental studies/ecology, and civics or citizenship education. These two subjects continued to be linked and they are at the basis of a debate among environmental education practitioners regarding the nature of environmental education. Some perceive it more as Environmental Ecological Scientific literacy, an independent branch of science, providing objective factual knowledge. Others consider it as Environmental sustainability citizenry literacy, an area of knowledge that deals to a large extent with ethical, social, cultural and value laden considerations (Cairns, Jr., 2002; Callicott, 2013, 2004; Hadjichambis et al., 2020; Leopold, 1949).

There are also calls to reconcile the different opinions and integrate the two (Berkowitz et al., 2005; Orr, 1990, 1994). These scholars argue that environmental education should include both components: "Environmental or ecological literacy", a significant component of which is scientific knowledge and "Environmental citizenship literacy", the understanding of political and economic social systems that involve ethical dilemmas related to sustainability and responsible environmental behavior. The synthesis of the two approaches according to these scholars, leads to "Environmental Civic literacy" that also contains personal value awareness, and the capacity to act in response to these personal values toward responsible environmental behavior.

In the past few decades, the international, as well as the Israeli, discourse on environmental issues has changed from being based on the first approach to the other approaches. Following this change, I traced whether this tendency was also seen in the nature of tests conducted in the international comparative studies of educational achievements, specifically those of the International Association for the Evaluation of Educational Achievement (IEA) and whether this was reflected in the achievements of students who participated in them.

The IEA was established in the late 1950s by a group of university researchers from various countries (Husén & Postlethwaite, 1996; Pizmony-Levy, 2013; Purves, 1987). This group had the idea of measuring the output of educational systems worldwide and examining the relationship between educational achievement and other educational variables, including the national curricula, and actual school and classroom-based practice. The scholars perceived the study as an investigation in a worldwide laboratory. The educational outputs were defined according to the formal curriculum in each of the participating countries. Often, there was a relationship between the countries' achievements and the topics taught according to the national curriculum. However, since the study

was a comparative one, it was necessary to decide on a common curriculum framework that would be applicable in all countries and define what pupils at a certain grade level should know and be able to do in terms of knowledge and performance (Robitaille et al., 1993; Robitaille & Maxwell, 1996).

The development of such a framework necessitated the involvement of representatives from all participating countries. Since the study is a longitudinal one, prior to each cycle of the study these representatives were asked to relate to a list of contents and cognitive skills and state whether they are part of their national curriculum and if not, whether they should have been included. Those contents and cognitive skills that were agreed upon by more than 70% of the country representatives were included in the Assessment Framework of the study.

In the present study, I track changes that occurred in the achievements of Israeli 8th grade students in environmental topics in the different cycles of TIMSS - 1995, 1999, 2003, 2007 and 2011) studies, that Israel participated, in and relate them to changes in the TIMSS curricular framework that reflect a global consensus regarding the place of environmental education in formal schooling, and to changes in the place of environmental topics in the local Israeli curriculum. These changes were analyzed at the level of individual items that reflect either the "ecological environmental scientific" approach or the less factual, science oriented "environmental sustainability citizenry" approach.

Since international, as well as Israeli, discourse on environmental issues changed over time from being based on the first approach to the second approach, we traced whether this change was also seen in the nature of the TIMSS tests and was reflected in the achievements of eighth graders in Israel. The research questions are:

1. How are environmental topics represented in the TIMSS Assessment Framework in the different study cycles?
2. Are there changes in the number and proportion of test items that represent the different educational approaches in each of the study cycles?
3. To what extent do the achievements of eighth-grade Israeli students mirror the different educational approaches in environmental studies?

Changes in International Public Awareness toward Environmental Hazards and their Impact on Environmental Education

Since the beginning of the 20th century, public interest in environmental issues has grown and awareness of the severity of environmental problems has increased. Whereas at the beginning of the 20th century the dominant discourse was a romantic one, based on spiritual, aesthetic, and religious values that supported leaving nature as is, the ongoing evidence of the severe consequences of population growth and human intervention on the environment changed the environmental discourse. The new focus was on the relationship between human health and the public wellbeing and the quality of the environment. Rachel Carson's classic book *Silent Spring* (1962), which first raised public awareness of the environmental risks of man-made chemicals is an example of this discourse. Palmer (2002) identifies shifts from an emphasis on nature study and fieldwork in the 1960s to outdoor education, conservation education, and urban studies in the 1970s, to global education and development education in the1980s, and, finally, to themes of empowerment, community, and sustainability in the 1990s and beyond. In the 1970s, human rights education also became a central theme (Eide & Thee, 1983; Meyer Bromley & Ramirez, 2010, p. 123).

With this shift, the notions of the human individual as an empowered actor, and the rhetoric in environmental education moved away from passive approaches emphasizing factual knowledge, toward a more active pedagogy emphasizing concrete lifestyle changes to protect the environment

(Palmer, 2002, p. 172). This move was backed by many meetings worldwide. In the following section, I elaborate on these meetings and describe the resulting change in environmental discourse.

In a series of conventions on Environmental Education that took place in the 1970s (UNESCO/UNEP 1972, Stockholm, Belgrade 1975) and the Intergovernmental Conference on Environmental Education (UNESCO/UNEP, 1977), it was determined that the deteriorating state of the environment requires assistance from the educational sphere. As a result of these conventions, attention was given to Environmental Education (EE). A formal definition of environmental education was developed, which stated the desired content of teaching about the environment. It included: facts and concepts (knowledge), teaching in the environment (process/pedagogy), and teaching to care for the environment (awareness, attitudes, skills, and participation). Several targets and aims of environmental education were defined:

- Obtaining knowledge: concepts, principles and processes.
- Creating awareness about risks and hazards that threaten the environment.
- Acquiring learning habits such as inquiry learning, problem solving, and decision-making skills and acting on them.
- Developing positive attitudes toward the environment and a willingness to act toward improving it.
- Adopting proactive environmental behavior and taking real action to improve the quality of the environment.

During the 1980s, the public discourse on environmental issues changed. In a document about strategy for conserving the world's resources (IUCN- International Union for Conservation of Nature and Natural Resources, 1980), the term "Sustainable Development" was used for the first time. The report argues for development to be sustainable, it should support conservation rather than hinder it. This term refers not only to environmental resources, but also to economical, agricultural, industrial, societal, and educational resources. The idea behind the term is to plan and act for the lives of future generations.

Following the IUCN report, The World Commission on Environment and Development, presented in 1987 another report, titled "Our Common Future" (also termed after its chairman the Brundtland Report, 1987), that emphasized the over-consumption of natural resources. It called for a strategy that united development and the environment and defined sustainable development as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Defining the need for Sustainable Development was the basis for international collaboration at the United Nations Conference on Environment and Development (United Nations 1992b). The conference's concluding document, Agenda 21 stated that: "There is a need to increase people's sensitivity to and involvement in finding solutions for environmental problems. Education can give people the environmental and ethical awareness, values and attitudes, skills, and behaviors needed for sustainable development. To achieve this, education needs to explain not only the physical and biological environment, but also the socio-economic environment and human development" (United Nations 1992a, sec. 36).

Ten years after the Rio convention, another convention took place in 2002 in Johannesburg. Ahead of this convention, the "Earth Charter" was drawn up, which made a connection between the environment and human rights and introduced the concept of Environmental Justice to the environmental discourse. Following this convention, Education for Sustainable Development (ESD) has gained momentum and the Commission on Sustainable Development (CSD) was created. (Wals

2012). The principles of sustainability influenced the nature of environmental education and the concepts of social justice and sustainable development became central to the curriculum.

Many countries, including Israel, decided to adopt the principles of sustainable development, that combine "a dynamic economy, wise use of natural resources, protection of ecological systems and offering equal opportunities to all, with the aim of attending to the needs of the present generation and that of the coming generations." (Government of Israel, decision 246, 14.5.2003).

Changes toward the Environment and toward Environmental Education in Israel

The worldwide changes in public awareness toward the environment were also seen in Israel. During the first half of the 20th century, before the founding of the State of Israel, attitudes toward the environment in Israel mirrored the international trend of preserving nature. This trend was in keeping with the Zionist ideology of returning to the landscapes of the homeland and of farming the land (Pizmony-Levy, 2011; Schwartz, 1997).

The State Education Law – 1953 (Government of Israel, 1953), enacted after the foundation of the state, also reflected this attitude to the environment and expressed the desire "[t]o plant in the heart of the pupils an intimate feeling toward the piece of land they are farming…A wish toward country life as a desired form of life both for the health of the body and the soul and for fulfilling the aims of building and fortifying the country". The appreciation of, and responsibility for, nature became one of the Ministry of Education's priorities. Learning in schools was in accordance with this declaration. Environmental studies were taught mostly as part of what was termed Homeland studies: Nature studies, Biology, Agriculture and Geography, and through extra-curricular activities in non-formal settings such as hikes, summer camps and youth movements.

In the 1960s and 1970s, the inquiry trend in science education that appeared in many countries also penetrated Israeli environmental studies. Environmental studies were taught as part of Agriculture, mainly learning through inquiry about the negative effects of human intervention on the environment such as pollution (Blum, 1979).

In the 1980s, a new curriculum for high school was launched, with two learning sections relating to environmental studies: the first dealt with ecological systems, the impact of technology on the environment, renewable and nonrenewable resources, and environmental management. The second section was an inquiry project that dealt with environmental topics. It is important to note that in the new curriculum, the ethical and value considerations of environmental decision making were not given much attention at that time.

Since the 1990s, the quality of the environment remained a central component of the environmental curriculum. In 1993, the just-established Ministry of the Environment announced the 1993/4 year as the "Year of the Environment in Israel." In 1999, the Ministry of Education introduced a revision to the National Education law, making an environmentally knowledgeable citizenry one of the Ministry's objectives.

Following the government's decision to adopt the principles of sustainable development, government ministries were required to develop strategic plans for this purpose. The Ministry of Education responded, and on 1.1.2004, published its policy document: "Implementing education toward sustainable development in the educational system." This circular was the first to mention the concepts of sustainability and environmental literacy, and to state the aims of educating toward sustainable development: "To raise among students an awareness, understanding and respect for the environment they are living in, and assure their commitment to sustainable development on all levels: personal, national and global (Ministry of Education, 2004). This marked a revolution in environmental studies (Wisenstern, 2004). The name of this subject changed from" Environmental studies" to "Environmental sciences", it was recognized as an elective subject, and the Center for

Science Teaching took charge of teaching it. However, decisions regarding the nature of the school subject only became value laden a decade later.

The curriculum developed in the spirit of this circular contained new topics such as Environmental economy, Environmental law, Environmental ethics, and the conservation of a diversity of species. The curriculum was intended to offer students not only knowledge and inquiry skills, but also values, attitudes and responsible behavior toward the environment. In December 2004, a document dealing with the priorities concerning the "Quality of the Environment" was presented to the Commission on Education in the Israeli Government (Tal, 2004). The document recommended that Environmental studies be a compulsory part of the curriculum at all school levels (K-12 and academic institutions) and one of the subjects that could be studied to lead to matriculation certification (Tal, 2004). It also recommended that teacher training in Environmental studies be upgraded, and that social engagement of students in these fields be promoted.

The National Council for the Quality of the Environment published a report (Goldman, 2004) that criticized the lack of coordination between the various bodies dealing with Environmental Education, and the fact that this field is not taught as an independent subject, but rather as part of other subjects, in which Environmental contents are only partially implemented. Environmental sciences only became an independent school subject in the 2010-11 academic year, and only in the upper grades of high schools. The report also criticized Environmental education for not being orientated toward sustainability. However, in the various circulars of the Environmental studies supervisor in the Ministry of Education (2007, 2008, 2012), a slow transition emerged from emphasis on contents and inquiry skills toward social issues and responsible behavior. In 2012, the Environmental studies supervisor circular states that "the curriculum focuses on understanding the interrelationship between man and his natural and human environment with a systemic-holistic view. Emphasis is placed on developing codes of moral-ethical behavior in order to foster affinity and positive attitude toward the environment. The program encourages engaging with environmental issues and dilemmas that are happening in Israel and around the world. A didactic principle at the heart of the program is a combination of learning in school and in the environment with active involvement and citizenship" (Environmental Studies Supervisor Circular, 2012).

An additional reason for the late appearance of the sustainability notions in Environmental education in Israel, stems from its dual subordination to two governmental bodies: the supervisors of the Pedagogical Secretariat of the Ministry of Education who are responsible for what and how the subject is taught in secondary schools, and the Directorate of Science and Technology which is responsible for Environmental education in elementary and lower secondary schools. Each of these two bodies views Environmental studies differently. The Pedagogical Secretariat views it as part of science education, believing in the power of scientific research to solve environmental problems. The Directorate of Science and Technology places more emphasis on values and activist thinking - in line with ideas of sustainability (Pizmony-Levy, 2011).

As sustainability became more popular and had a greater presence in the curriculum, it was expected that it would have an effect on students' achievement in this field. The opportunity to examine whether this expectation has been realized arose when Israel participated in the International comparative studies of the International Association for the Evaluation of Educational Achievement (IEA) association, amongst them the TIMSS study - Trends in International Mathematics and Science Study that examined, among other fields, Environmental studies and student achievement in this area.

Data and Method

This paper examines the effect of changes in the discourse of the Environmental movement, both worldwide and in Israel, on the achievements of eighth-grade Israeli students in environmental topics. The data on achievement is based on Israeli TIMSS data obtained in the 1995, 1999, 2003, 2007, and 2011 study cycles (Nachmias & Zuzovsky 2008; National Authority for Measurement and Evaluation in Education, 2011; Zuzovsky, 2001, 2005; Zuzovsky et al., 1998).

The topics that cover environmental issues were derived from the International Assessment Frameworks that were developed toward each of the study cycles and reflected international consensus. The framework dictated the content and the cognitive characteristics of the test items. These represented two distinct approaches in environmental education. The first focuses on scientific knowledge related to the ecosystem and the relationship between its components and is known as the "Environmental scientific literacy" approach. The second approach views this knowledge through a value laden perspective, taking into consideration the consequences and ethical dilemmas involved in responsible environmental behavior that assure sustainability, and is known as the "Environmental sustainability citizenry literacy" approach. The use of the term literacy in the framework extends beyond the ability to read and write to compatibility in other fields. UNESCO defines it as a Continuum In the field of environmental studies, McBride et al. (2013) make a distinction between three types of literacies. Two of them, Environmental and Ecological literacies are more in line with what we call the "environmental scientific literacy" approach and one termed Ecoliteracy is more in line with "citizenship or civics literacy" approach.

To track the changes that reflected the transition from teaching and learning according to the "environmental scientific literacy approach" to the more social "environmental sustainability citizenry approach", we preferred to categorize all test items into three groups. The first deals mainly with scientific facts and concepts that describe the ecological system and the relationships between its components. This group of items represented the "scientific literacy approach". These items still remained part of the ecosystem theme in the Biology domain. The other two groups represented more the "sustainability citizenry" approach and dealt with changes in the environment due to natural and man-made hazards, and ways of coping with them. For example: population growth, management of resources, pollution and other environmental changes.

The measure used for reporting student achievement was the percentage of correct answers (Proportion correct) of a group of students for each of the test items. This measure is not used to measure individual's achievements, but rather to measure the group's achievements. A score of 100% means that the group of students accumulated the maximum possible score points for a certain test item or the mean possible point score of a group of items that belong to the same topic. A lower percentage score indicates only the partial score points accumulated by the group out of the maximum possible score points. These type of scores are discussed in TIMSS 2007 Technical Report 2008 (Olson et al., 2007)

The achievement data was obtained from the TIMSS official Israeli almanacs for science items (weighted) in the study cycles 1995, 1999, 2003, 2007, and 2011. We used all the items appearing in the almanacs, the released items for illustrative purposes, the new ones that replaced older items in each study cycle and those kept for measuring trends. Since the 1995 Israeli sample did not include Arab students, whereas they are included in all the other cycles, we report only on achievements from 1999.

Results

The Representation of Environmental Topics in the Assessment Framework of TIMSS

The Assessment Framework of the TIMSS study expressed wide international consensus. However, since there have also been changes over time, the framework had to be revised prior to each cycle of the study. The first framework was developed for TIMSS 1995 (Robitaille et al., 1993; Robitaille & Maxwell, 1996) and was also used for TIMSS 1999. This framework defined eight broad categories of content: earth sciences, life sciences, physical sciences, science technology and mathematics, history of science and technology, environmental and resources issues, nature of science and of the other disciplines. Environmental issues appear as an independent topic among the eight. Within these broad categories, there were specific topics which were listed as sub-categories.

Environmental topics in both the 1995 and 1999 frameworks were categorized into two groups. First, as part of the life sciences category, they were called "Interaction of Living Things" and contained the following topics: Biomes and ecosystem, habitats and niches, interdependence of life and animal behavior. The other group, "Environmental and Resources Issues", contained topics on pollution, conservation of material and energy resources, world population, food production and natural disasters. Thus, a distinction was made between topics describing the ecosystem and those describing human intervention in the environment. The first group dealt with scientific ecological aspects of Environmental sciences and the second one with sustainability aspects. This major distinction was kept throughout all the cycles of the TIMSS studies.

The cognitive performance categories contained five categories: 1) understanding, 2) theorizing, analyzing and problem solving; 3) using tools, routine procedures, and science processes; 4) investigating the natural world; and 5) communicating. Each of these categories is further divided into a number of subcategories that have an instructional or learning focus. For example, understanding progresses from simple to complex and thematic information. Communication progresses from accessing to sharing information. Investigating the world is a set of inquiry skills progressing from identifying questions to formulating conclusions. This category appears in later frameworks as a separate assessment strand that overlaps all the fields of science and has both the content and skill-based components.

In TIMSS 2003, only five major content domains remained to define the science content: Life Sciences, Chemistry, Physics, Earth Sciences, Environmental Sciences. Other content domains appearing in the previous cycles 1995, 1999, such as History of Science, Nature of science and Science and other disciplines, were omitted. While environmental science is not typically offered as a separate science course until at least the upper secondary or post-secondary level, its inclusion in the selected TIMSS major content domains framework as a separate content domain reflects the relative importance placed internationally on educating students about factors affecting the environment and the ecosystem.

The environmental science category in TIMSS 2003 is defined primarily by understandings related to the interaction of humans with ecosystems, changes in the environment due to man-made or natural events, and protection of the environment. An underlying theme throughout is the roles and responsibilities of science, technology, and society in maintaining the environment and conserving resources (Mullis et al., 2003 p. 58).

The developers of the curriculum framework regarded environmental science as a field of applied science concerned with environmental and resource issues. As such, it involves concepts from the life, earth, and physical sciences with a considerable overlap among them. Defining Environmental science as an applied field of research expresses a common view of using scientific knowledge and already known solutions to solve environmental problems. The concept of the

ecosystem that focused on environmental literacy appears among the topics of life sciences and not among the topic of environmental sciences. The distinction that appeared in 1995 and 1999 between topics related to the concept ecological system (scientific approach) and the interaction between the environment and humans (sustainability citizenry approach) still exists.

The skills and abilities that illustrate student understandings are classified into three broad cognitive domains: factual knowledge, conceptual understanding, and reasoning and analysis. *Factual Knowledge* refers to students' knowledge base of relevant scientific facts, information, tools, and procedures. *Conceptual Understanding* means students should be able to demonstrate a grasp of the relationships that explain the physical world and relate the observable to more abstract or general concepts. *Reasoning and Analysis* includes problem-solving and scientific reasoning processes involved in the more complex tasks related to science. Items may require students to analyze/interpret problems; integrate/synthesize a number of factors or related concepts across mathematics and science; hypothesize/predict; design investigations and procedures; analyze/interpret data; draw conclusions; generalize; evaluate; and justify explanations and problem solutions.

The TIMSS 2007 Assessment Frameworks document closely resembled that of TIMSS 2003 (Mullis et al., 2003). Since it is crucial to have continuity in a study designed to measure trends in educational achievement over time, this is very appropriate. However, there are some notable revisions in the content and cognitive domains that followed changes in the curriculum. As in the previous cycles of the study, the science assessment framework for TIMSS 2007(Mullis et al., 2005) was organized around two dimensions, a content dimension specifying the domains or subject matter to be assessed within science (for example, biology, chemistry, physics, and earth sciences in eighth grade) and a cognitive dimension specifying the domains or thinking processes to be assessed. The environmental topics appear as part of the life sciences and the earth sciences major categories. In the life sciences domain, they appear in biology as the study of ecosystems, which is an essential topic for understanding the interdependence of living organisms and their relationship to the physical environment. The earth sciences category contains knowledge of Earth's resources and their use and conservation by providing examples of renewable and non-renewable resources, by relating the effects of human use of land resources to methods used in agriculture, and by discussing the factors related to the supply and demand of fresh water and other global effects such as global warming, desertification. etc. Again, this division distinguishes between the environmental "scientific" approach and the human intervention "sustainability citizenry" approach. The emphasis on environmental global problems reflects concerns for sustainability rather than for ecological literacy.

The cognitive dimension in TIMSS 2007 is divided into three domains. The first domain is *Knowing*, focusing on scientific facts, procedures and concepts students need to know. The second domain is *Applying*, focusing on the student's ability to apply knowledge and conceptual understanding to solve scientific problems. The third domain is *Reasoning*, which goes beyond the solution of routine science problems to encompassing unfamiliar situations, complex contexts and multi-step problems. The major purpose of science education is to prepare students to engage in scientific reasoning to solve problems, develop explanations, draw conclusions, make decisions, and extend their knowledge to new situations. Among the abilities, two are important: Evaluate - weigh advantages and disadvantages to make decisions about alternatives; and Justify - explanations and solutions to problems.

The environmental topics included in the science Assessment Framework of TIMSS 2011(Mullis et al., 2009; Mullis et al., 2011) consist of topics related again to biology from the life sciences category and topics from the earth sciences category. Biology is the most emphasized content domain in the life sciences assessment framework. It includes the study of ecosystems,

which is a core topic in environmental studies and is essential to understanding the interdependence of living organisms and their relationship to the physical environment. It describes the flow of energy in an ecosystem; identifies different organisms as producers, consumers, and decomposers; draws or interprets food pyramids or food web diagrams, the role of living things in the cycling of elements and compounds, explains the interdependence of populations of organisms in an ecosystem, identifies factors that can limit population size, predicts effects of changes in an ecosystem and discusses the effects of population growth on the environment.

Environmental topics from the earth sciences category which are less covered, include knowledge of Earth's resources and their use and conservation such as: water, land, and environmental concerns such as: pollution, global warming, acid rain, data or maps relating global and local factors to weather patterns, and the differences between daily weather changes and general climate in various regions of the world.

The cognitive domain in TIMSS 2011 is identical to that used in TIMSS 2007. Knowing refers to students' knowledge base of scientific facts, information, concepts, and tools. Applying questions in this cognitive domain are designed to involve the direct application of knowledge and understanding of science in straightforward situations. Reasoning is used in the more complicated contexts that require students to look for a strategy for problem solving and justify their solution using value laden arguments. This requirement fits the sustainability citizenry approach for solving environmental problems and dilemmas.

The Representation Over Time of Environmental Topics in TIMSS Achievement Tests

Reviewing the items dealing with environmental issues in the different TIMSS cycles revealed three main topics: The Ecosystem - its components and their interrelations; Changes in the environment due to human intervention and due to natural hazards; and Natural resources and their conservation. The first topic represents the scientific approach while the other two represent the sustainable citizenry approach.

The importance given to the various topics in the test can be deduced from the proportion of items dedicated to each of the different topics in the various study cycles. The proportion of items that represent the importance of the whole content domain can be deduced from the total number of the items that cover all environmental topics.

Table 1 shows a gradual increase from 1995 until 2007 in the number and proportion of test items that belong to each topic, as well as the increase in the share of environmental items in the whole test (an increase from 10% to 25%). In 2011, there was a decrease in the representation of environmental test items. While there was an increase in the number of items covering the topic of the ecological system (scientific approach), from 38% to 56%, the proportion of the number of items in the two other topics that were in line with the sustainability citizenry approach remained static or even decreased.

Table 1

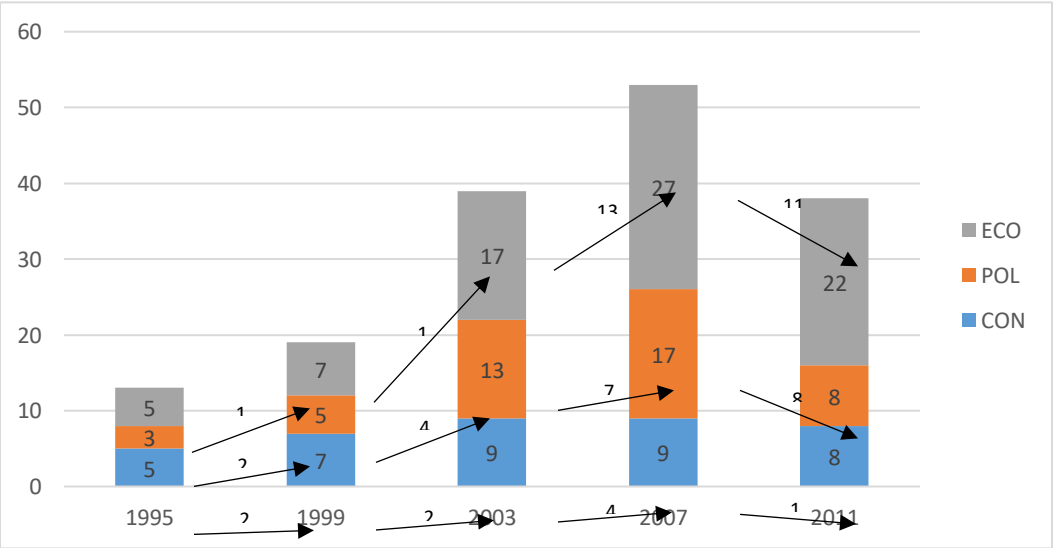
Changes Over Time in the Number and Proportion of Test Items Representing Different Environmental Topics from the Total Number of Items in Each Topic and Total Number of Test Items

Topics	1995	1999	2003	2007	2011
Ecological Systems (ECO)	5 (38%)	7 (37%)	17 (44%)	27 (51%)	20 (56%)
Changes in the environment (POL)	3 (23%)	5 (26%)	13 (33%)	17 (32%)	8 (22%)
Recourses and their conservation (CON)	5 (38%)	7 (37%)	9 (23%)	9 (17%)	8 (22%)
Total number of Environmental items	13	19	39	53	36
Proportion of Environmental items out of total test items	10% (135)	13% (146)	20% (198)	25% (214)	15% (242)

The changes that occurred in the representation of environmental test items can also be seen in a diagram. Fig. 1 shows the growth in the number of test items that represent the three main topics: ecological system (Eco); changes in the environment (Pol); and resources and conservation (Con). The topic that deals with the ecological system, represents the scientific approach while the topics that deal with environmental hazards and conservation issues are more related to the sustainability citizenry approach. The numbers appearing above the arrows in the figure indicate identical items, called Trend items that appear in consecutive study cycles. These are called anchor items that are used to calibrate the measurement scale in the different study cycles.

Fig 1

Changes Over Time in the Number of Items Representing Environmental Topics



Characteristics of Test items that Represented Environmental Contents and Cognitive Skills

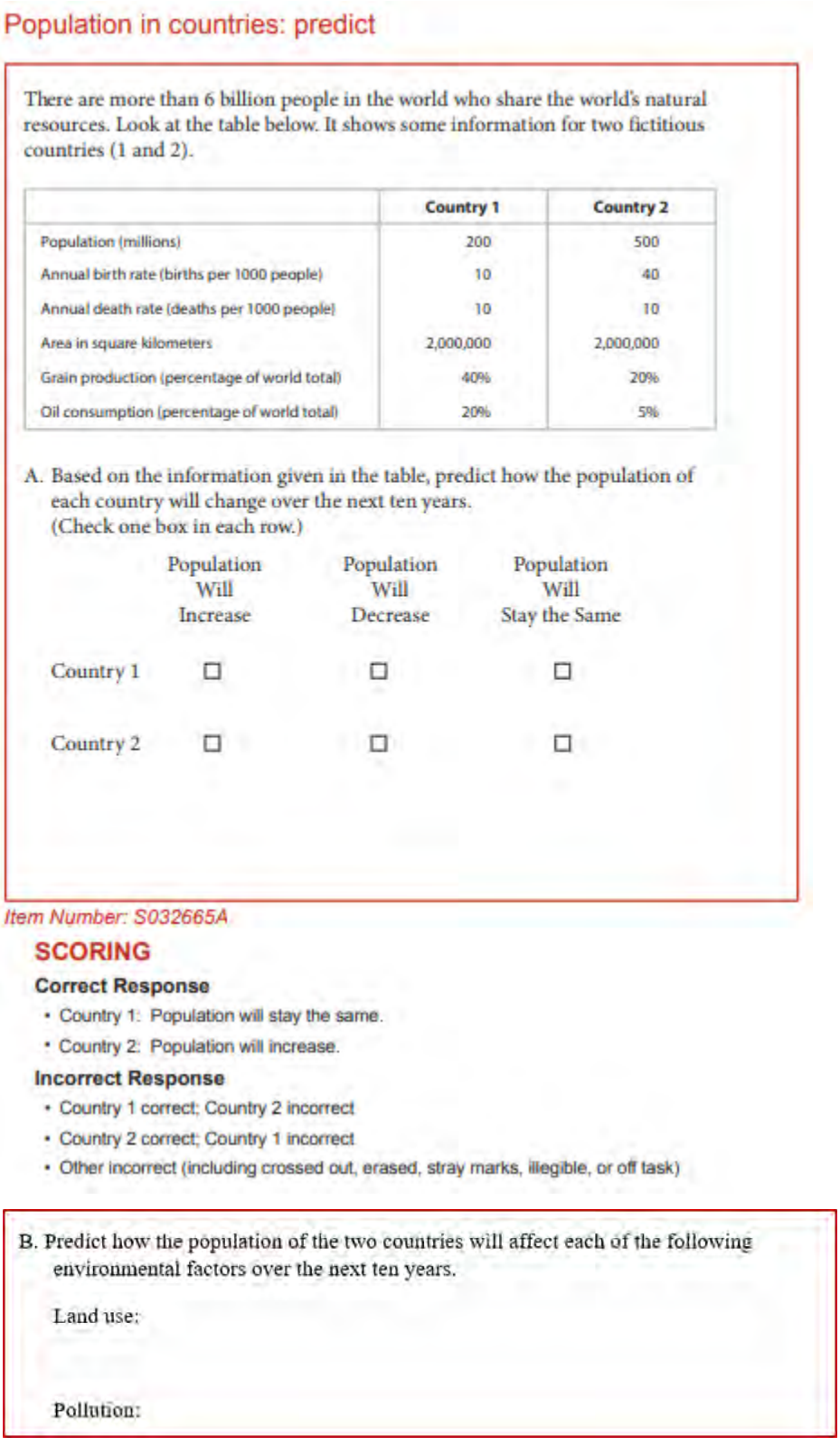
The items that were used to assess content and cognitive skills in the area of environmental studies represented the two approaches to environmental education. The environmental scientific approach aims to solve environmental problems through scientific knowledge, and the sustainability citizenry approach which deals more with the involvement of humans in the environment and its consequences. Even though today the sustainability citizenry approach is very popular both worldwide and in Israel, only limited number of test items appearing in international TIMSS science tests require students to exhibit value judgment regarding human intervention in the environment, which is a necessary characteristic for items according to the sustainability citizenry approach.

The cognitive category that best fits the sustainability citizenry approach is the reasoning category. In addition to the more direct applications of scientific concepts exemplified by the applying category, the reasoning category which requires students to look for a strategy for solving problems and to justify their solution using value laden arguments better fits the sustainability citizenry approach. This requirement fits the sustainability citizenry approach for solving environmental problems and dilemmas. Analysis of the cognitive aspects of the test items reveals that most of them do not express habits of mind that are in line with the cognitive demands of the sustainability citizenry approach.

The following example (Fig. 2) shows how an item focuses more on a scientific ecosystem topic in Biology and fails to catch the essence of sustainability ideas and remains only an example of applying biology knowledge. The item appears in TIMSS 2011 test and belongs to the Biology content domain, main topic-ecosystem and cognitive domain: reasoning. Students are asked, based on information given in the item, to predict changes in population size in two countries over time. Students are not asked to go beyond and suggest a solution to foreseeable problems and justify this solution based on value considerations. In section B of the question, they are asked in line with their previous prediction to further predict what the effect of two factors would be: the usage of soil and pollution. Examples of the answer given to the prediction are mechanical and flat. Regarding soil usage the response states: in Country 2 they will use more soil because of population growth. Regarding pollution: more pollution will occur in country 2 due to increase in population. The percentage of Israeli students who correctly answered the first sub-item categorized as an application item was 52%, and only 22% answered correctly to the other sub-item categorized as a reasoning item which fits the sustainability citizenry approach.

Fig 2

An example of an item in the Biology domain



Population in countries: predict

There are more than 6 billion people in the world who share the world's natural resources. Look at the table below. It shows some information for two fictitious countries (1 and 2).

	Country 1	Country 2
Population (millions)	200	500
Annual birth rate (births per 1000 people)	10	40
Annual death rate (deaths per 1000 people)	10	10
Area in square kilometers	2,000,000	2,000,000
Grain production (percentage of world total)	40%	20%
Oil consumption (percentage of world total)	20%	5%

A. Based on the information given in the table, predict how the population of each country will change over the next ten years.
(Check one box in each row.)

	Population Will Increase	Population Will Decrease	Population Will Stay the Same
Country 1	☐	☐	☐
Country 2	☐	☐	☐

Item Number: S032665A

SCORING

Correct Response

- Country 1: Population will stay the same.
- Country 2: Population will increase.

Incorrect Response

- Country 1 correct; Country 2 incorrect
- Country 2 correct; Country 1 incorrect
- Other incorrect (including crossed out, erased, stray marks, illegible, or off task)

B. Predict how the population of the two countries will affect each of the following environmental factors over the next ten years.

Land use:

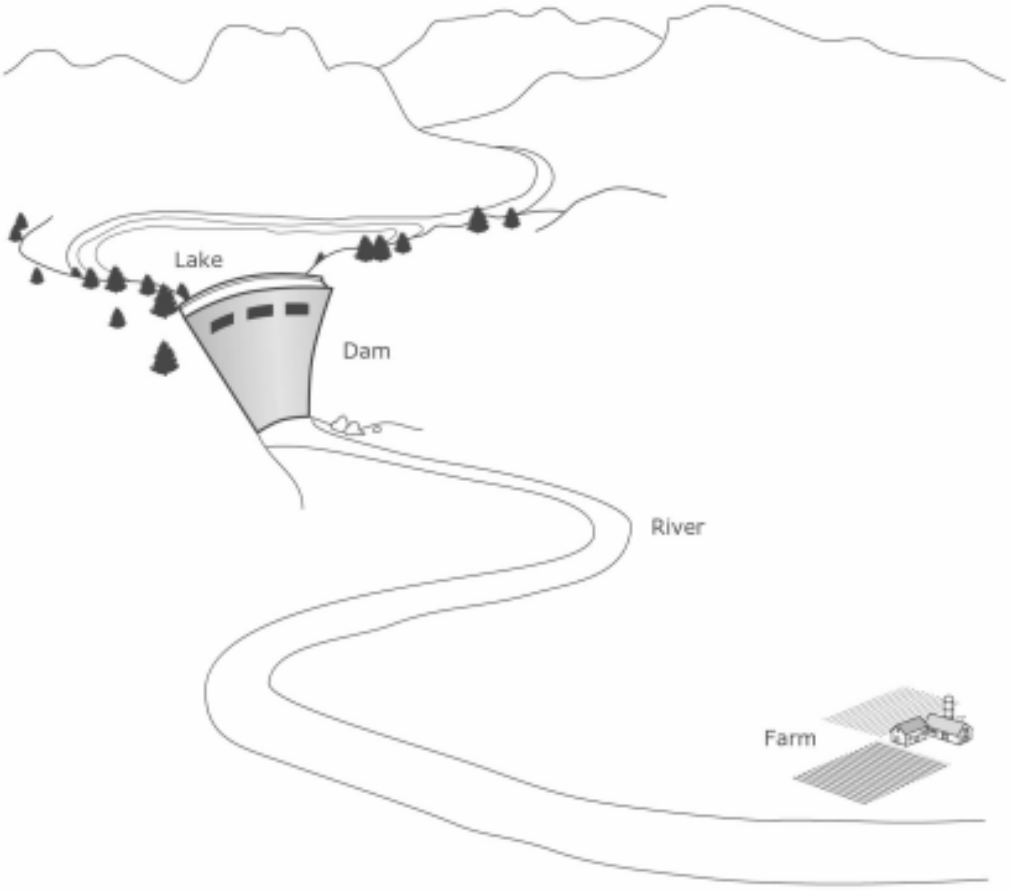
Pollution:

The following item (Fig. 3) is an additional example of the shortcomings of many of the items used in the test. The item is categorized as belonging to the conservation sub-domain of environment and to the cognitive category of reasoning. Students were asked only to predict positive and negative consequences of man's intervention in the environment, without relating to the dilemma of development versus conservation - which is the essence of the situation from the point of view of the sustainability citizenry approach. The item belongs to the sub-topic of conservation and requires reasoning and analysis cognitive skills.

Fig 3

An example of an item in the conservation sub-domain

The diagram shows a farm in a valley where a dam has just been built.



The presence of the dam can have both positive and negative effects on farming in the valley.

A. Describe one positive effect of the dam on farming.

B. Describe one negative effect of the dam on farming.

Changes Over Time in the Environmental Achievements of Eighth Grade Students

Table 2 presents the average percentage of correct scores of items belonging to the three main environmental topics in the study cycles conducted in the 1999, 2003, 2007, and 2011 TIMSS.

Table 2

Achievement (Average Percent Correct Score) of Eighth Graders in Israel in Environment Topics – TIMSS Results

Topics in the test	1999		2003		2007		2011		F&sig
	n	*X (SD)*	*N*	*X (SD)*	*n*	*X (SD)*	*n*	*X (SD)*	
Ecological Systems (ECO)	2,617	46 (45)	2,533	48 (43)	3,938	42 (41)	4,355	59 (38)	121.8***
Changes in the environment (Pol)	3,144	39 (43)	3,248	41 (36)	3,714	39 (37)	3,343	54 (46)	111.9***
Recourses and their conservation (Con)	4,192	42 (38)	2,521	39 (42)	2,561	33 (44)	3,314	52 (43)	116.9***
Total	4,195	45 (29)	3,961	41 (36)	4,174	38 (30)	4,689	54 (31)	206.6***

***$p \leq .000$

The achievements of Israeli eighth graders in environmental studied are moderate. They gained only half of the possible score points. The highest score was gained in 2011, seven years after the educational system decided to focus on environmental studies and adopt the sustainability citizenry approach in 2004. However, even after this decision was taken, the highest score achieved was in the topic of ecological systems that fits the scientific approach, and not in the topics that better represent the sustainability citizenry approach.

Discussion and Conclusions

This study examines the achievements of Israeli eighth graders in environmental sciences, and the extent to which they reflect the recent emphasis given worldwide and by the Israeli Ministry of Education to the sustainability citizenry approach in environmental education. Despite the Ministry's efforts to promote environmental education, only few studies have evaluated the outcomes of these efforts. Ben-Hur et al. (1996) examined knowledge and attitudes of junior high school student in environmental science, and Negev et al., (2008) assessed the environmental literacy of students in the educational system. The data obtained in these studies is not comparable to the data in the present one. The first dealt mainly with student awareness of environmental issues. The second measured environmental literacy among sixth, ninth and 12th grade students. The variability in the test scores obtained in that study prevents sound comparisons.

The most prominent outcome in the current study, is the moderate average correct score in all three topics that represent the curriculum of environmental studies, as well as in the whole set of

environmental items over all cycles of the study. There is an increase in the percentage of correct scores in 2011, which may be a sign that the Ministry's efforts are successful in this area. However, the improvements are mainly in the topic of ecological system (the scientific approach) and not in the two other topics that represent the sustainability citizenry approach.

Several explanations can be given for these findings. First, the interdisciplinary, or even the transdisciplinary nature of environmental science, their non-independent status in the curriculum, the lack of coordination among the bodies that are active in the field and the delay in implementing many decisions in favor of the sustainability citizenry approach that were announced over the years in the Ministry circulars (Vorgan, 2006, 2010).

The level of achievement may possibly have been affected by the low level of implementing the curriculum and the mismatch between the testing time and the time during which environmental topics were taught. An attempt to match the testing time with the learning time was deliberately made in 2003. Already in 2002, a year before the testing, the Directorate of Science and Technology and the science supervisors in the Ministry of Education published a detailed document with all topics that were going to be tested in TIMSS 2003 and in the national exams in science. Among these were topics related to 1. changes in human population and its impact on the environment; 2. using resources and their conservation; 3. changes in the environment. Teachers who taught life sciences and earth sciences were required to take these topics into consideration and teach them in time for the test. However even this attempt did not result in an improvement.

Another explanation for the disappointing results of Israeli eighth graders in environmental science is the dissonance between the statements and emphasis of Environmental Education in Israel and the nature of the international test that assessed this area. The international test focused mostly on scientific ecological knowledge and on the use of this knowledge for solving routine problems (applying) and not on the two other topics that were more in line with the sustainability citizenry approach topics of changes in the environment and conservation of resources. In this sense the TIMSS study did not assess civic literacy (Pizmony-Levy, 2010), the capacity of students to use ecological knowledge to solve value laden environmental problems that are related to issues of social justice. TIMSS tests do not require students to form their opinion regarding these moral issues. These are delt separately in CIVAD/ICCS studies

Criticism of TIMSS tests was voiced by other scholars, who noted that the tests were a "mile wide and an inch deep" (Schmidt et al., 1997), that they consist mostly of closed test items and avoid dealing with environmental issues (Atkin & Black, 1997). Bearing this criticism in mind, and together with our analyses that show that the international IEA test does not reflect the curricular changes that occurred worldwide and in Israel, caution is required in drawing conclusions about the attainment of environmental education worldwide and in Israel. The findings of this study should be a warning sign for educators and policy makers to pay more attention to the implementation of the decisions taken regarding environmental education and to properly monitor their effects.

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