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*Learning in Science in the
Mediterranean Region*

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and
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# AIMS OF THE JOURNAL

The *MJES* is a biannual refereed international journal with a regional focus. It features educational research carried out in Mediterranean countries, as well as educational studies related to the diaspora of Mediterranean people world-wide. The journal offers a forum for theoretical debate, historical and comparative studies, research and project reports, thus facilitating dialogue in a region which has strong and varied educational traditions. There is a strong international dimension to this dialogue, given the profile of the Mediterranean in the configuration of the new world order, and the presence of Mediterranean peoples in Europe, North America and elsewhere. The *MJES* is of interest to scholars, researchers and practitioners in the following fields: comparative education, foundation disciplines in education, education policy analysis, Mediterranean studies, cultural and post-colonial studies, Southern European and area studies, intercultural education, peace education, and migrant studies.

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EDITORIAL

# THE ROLE OF SCIENCE EDUCATION IN THE MEDITERRANEAN REGION

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*S* ocial structures in the Mediterranean basin have never aspired to either simplicity or homogeneity. That is not to say that one cannot find unifying attributes: a genuinely warm hospitality is immediately recognized by even the casual traveller to any part of the Mediterranean shores.

When in September 2002, we gathered for four days in Droushia, Cyprus, to reflect on science education around the Mediterranean, initially very little joined us. It is not just the strong influence on science education that has long been exerted by local historical and cultural traditions. The northern Mediterranean countries now have access to local and European research funding and are genuinely committed to an emerging science education research paradigm that aspires to offer a rigorous evidence – based platform from which to design and support the implementation of new science teaching and learning practices. The southern Mediterranean countries still grapple with the need for economic development and have to rely on the guidance of institutions such as UNESCO to lay the necessary foundation for achieving improved literacy rates in language, mathematics and science. On the eastern and north-eastern shores, conflict continues to evolve and, in that context, efforts to achieve security and to construct new national identities are bound to exert an influence on educational policy and practice. At the very centre of the Mediterranean, small island states strive with issues of governance and resource management in a world that is increasingly competitive on various scales.

## Globalization, postcolonialism and multiculturalism

Mediterranean societies are not new to all this; they have long been characterized by constant economic, political and cultural transformations, which create several tensions and complex dynamics across the region. Cultural, commercial, environmental, geopolitical, security, and military tensions have often been at the forefront of the relations between Mediterranean cultures. The region has for centuries been marked by conflicting differences and a number of unresolved crises. Several countries have been British or French colonies (e.g., Cyprus, Algeria, Malta,

Palestine) struggling to construct a postcolonial identity while still reflecting the cultural and knowledge traditions of their colonial forebears. Although Mediterranean societies are becoming more and more multicultural, partly due to globalization, some of them tend to avoid any reference to multiculturalism and prefer to identify themselves as strictly unicultural. Disrespect for minority cultures and cultural differences, as well as cultural intolerance, are also often reflected in various developments. Further, the antagonism between the 'north' and the 'south' regions of the Mediterranean is increasing: a 'north' that is more economically developed and is steeped in Catholicism and a 'south' that is underdeveloped and a home of Islam (Sultana, 1998). However, as Sultana (1998) warns us, Mediterranean unity and collaboration is a matter of survival, if we want to promote a culture of peace, justice and cultural tolerance.

Despite the fact that economic, cultural and educational trends in the different countries and societies occupy varying agendas and priorities, it is nevertheless possible to perceive a number of common characteristics among Mediterranean countries, which are worth noting. Among these, one can refer to a similar eco-environment that has created virtually identical ecological problems to Mediterranean peoples such as waste disposal, the impact of tourism on coastal ecology and limited water resources (Gilmore, in Sultana, 1998). Especially, the limitation of water resources in the face of increasing demand causes increasing problems and has often generated conflict. Using resources sustainably, especially freshwater, preserving critical ecological functions and reducing pollution are issues that have long dominated the political priorities for both national and cross-national policy making. Further, according to Gilmore, a uniform Mediterranean ecology led to a number of common sociocultural traits such as 'atomistic' community life, strong religious orientation, an emphasis on shifting, noncorporate coalitions and intense parochialism. Finally, another common characteristic is the struggle of Mediterranean countries to avoid marginalization by the economic and political core that often comes from former colonial powers. Such common characteristics provide an important context and channel for the elaboration of the relationship between education and culture, and of an account of the possibilities for change through collaboration.

## The contribution of learning in science

One of the issues that came up in Droushia is the common need, throughout the Mediterranean countries, to connect science learning to citizenship, critical discourse and decision making. Transformative action that enters into any attempt at communication is clearly illustrated by one of the papers in this special issue

in the context of teacher transformation of innovative curricula in Spain and Italy. How do we safeguard science learning for all was also a joint concern, in a region which to a large extent relies on imported expertise that often ignores the local constraints and anticipations. The influence of UNESCO, in its perpetual effort to facilitate modernization by transferring recently evolved practices in the west to markedly different contexts, is evident in the paper from Palestine, where on the one hand the conflict with Israel is exerting an enormous toll on education and, on the other hand, the effort to build a system has to be applauded and admired. The struggle of many Mediterranean countries to develop ideas but also to take ideas, to adapt, to transform, to reflect and to write back is evident in many of the papers. The strain between local and global and the varied contexts of countries which traditionally are producers as compared to receivers of science knowledge, paint a mosaic of educational systems striving to claim a generative role in global science education.

A number of important drivers sustaining change in science education are identified. Firstly, on the global level, the knowledge society scenario promoted by the European Union implies, for instance, increased emphasis on lifelong learning skills and greater importance for the development of flexible thinking skills and capabilities such as meaningful navigation through knowledge. What cognitive resources are required for this and how do they relate to science education is one of the issues that remains open. The other important driver is the emerging science education research tradition, which in itself is also undergoing transformation from a process of generating new ideas about science teaching and learning to designing successful practice as a means of further elaborating theory in unison with an explicit view to improving the quality of learning.

Religion is the third of the driving forces that exert a strong influence in Mediterranean educational systems. In Arab countries, the tendency to begin each topic in the textbooks with a verse from the Koran is both perplexing and interesting, at the same time. In Palestine, one of the declared objectives of the science curriculum is to 'reinforce faith in God'. Apart from overt constraints, we also discovered some hidden resources: Fischbein in Israel and Baltas in Greece, whose writing may not be widely available in English, provide valuable epistemological support in their respective countries, thereby providing thoughtful local resources to any effort to attain reform.

The science for all trend that could be recognized in all countries is strongly reflected in the papers from Greece. The combination of formal and informal aspects of science learning into a non-formal paradigm presents an avenue for extending meaningful education outside school walls and into society, addressing differentiated learning styles and attracting younger people into scientific inquiry.

A number of the papers address ecological topics and the ways they could fruitfully be advanced through the educational system. The earth systems education approach takes a holistic perspective from the point of view of dynamic systems. In this context, and in the paper on water education from Israel, the issue of linking science learning to decision making capabilities reemerges alongside the need for situating science education in contexts that are relevant to the local society. For small and large countries alike, water is an issue of grave concern. It is also explored as a topic that can be addressed from multiple perspectives and an issue that could benefit from systematic analysis and thoughtful, caring approaches. In the paper from Israel, water management is used as a medium for peace education.

In this and other contexts, the importance of synergies re-emerges. For instance, it turns out that the design and development of effective curriculum, which engages many of the papers, requires collaboration between science education researchers, classroom teachers and other agents in the educational system.

Education, as well as collaboration in education among Mediterranean countries, is of central importance in trying to understand the tensions and face the challenges in this region. Science education, in particular, can contribute to the tensions and challenges faced by Mediterranean societies by promoting peace and prosperity. These are high priority areas of strategic importance for this region, as well as for the European Community and the Middle East. To focus on these goals, education in general and science education in particular should promote regional reforms that would lead to sustainable growth and improved living standards of the people of the Mediterranean.

The Droushia Seminar ended on a positive note. Our beliefs, interests, goals and value systems resonated in the end. We recognized value in the Mediterranean identity and cherish this with our other identities. Following the Droushia Seminar, authors made changes to their original manuscripts responding to mutual review efforts. The revised manuscripts were then reviewed by two anonymous referees each; all seven reviewers involved agreed to retain their anonymity. We would like to thank all reviewers and all colleagues who submitted papers for this special issue. Those whose work is published in this volume demonstrated remarkable patience and perseverance. Those who did not make it are sincerely thanked for their efforts, their valuable ideas and the contribution to the Droushia Seminar. We feel proud of the hard work during and after the seminar and as science educators, we submit the group's work and ideas as a small contribution to the formation of a critical discourse on learning in science in the Mediterranean in the interests of promoting peace, justice, tolerance, and environmental insight.

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# SCIENCE CENTRES AS SITES FOR LEARNING: THE CASE OF A GREEK ENVIRONMENTAL CENTRE

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**Abstract:** *Given the lack of exploratory orientation of science education in most of the Mediterranean countries, Science Centres could enrich our efforts to teach the investigative nature of science more effectively. This study aims at presenting a grid for analyzing the pedagogical implications of the exhibits' design in a science centre. The construction of the grid is based on the theoretical notions of classification, formality and framing. The representational modes employed in a science centre (e.g. written language, formatting and layout of written text, two- and three-dimensional representations, lighting, etc) contribute to the modulation of the levels of classification, formality and framing. In order to illustrate the potential of the grid, we used it to analyze some of the exhibits of the 'Gaia' Environmental Centre in Greece. The results demonstrated that science is presented as a specialized body of knowledge (strong classification), in this case, expressed in vernacular and realistic codes (low formality) and consisting of elements that can be discovered through active personal involvement (weak framing). These results show that the design of a science centres' exhibits can potentially allow students to have access to the cognitive landscape of the specialized scientific knowledge by removing the barriers of the specialized expressive codes and by treating them as active explorers.*

## Introduction

*S*cience centres have been recently recognized as sites where the investigative and experimental nature of science can be effectively encountered by students (Falk and Dierking, 1992; Beiers and McRobbie, 1992; Crane, Nicholson, Chen and Bitgood, 1994; Henriksen and Jorde, 2001). 'Science centres' are institutions that are clearly distinguished from the more traditional 'science museums' in the sense that they demonstrate a shift in focus from the classical exhibition of objects of cultural heritage for ocular observation (as is the case in most of science museums) to the open-ended manipulation of exhibits. Hence, science centres typically aim to enable visitors to engage with processes and build an understanding for the fundamental concepts of science, thus bringing the notion

of the scientific exploration into the exhibition hall (Oppenheimer, 1968; Gregory, 1989; McManus, 1992). We use the term 'science centres' to label collections of *interactive* exhibits in 'which visitors can conduct activities, gather evidence, select options, form conclusions, test skills, provide input, and actually alter a situation based on input' (McLean, 1993).

Given the lack of experimental and exploratory orientation of science education in most of the Mediterranean countries in comparison to the North European countries (Solomon and Gago, 1994), science centres could enrich our efforts to teach the nature of science more effectively.

Additionally, although science centres are well established in the Northern European region, they have only recently started to spread around the Mediterranean basin (Table 1).

TABLE 1: *Number of science centres in the Mediterranean region. Only 5 members of the European Collaborative for Science, Industry, and Technology Exhibitions Network (ECSITE) are included.*

| Country | No of Science Centres |
| --- | --- |
| Italy | 24 |
| Spain | 20 |
| Portugal | 7 |
| Greece | 2 |
| Tunisia | 1 |
| Turkey | 1 |

Source: ECSITE website: http://ecsite.ballou.be/net/beta.asp

Table 1 only includes the larger science centres in terms of the area covered by their exhibits and the number of visitors they attract and excludes many small regional centres that have not joined ECSITE.

Despite the currently restricted diffusion of the 'science centres' concept in the Mediterranean countries, such institutions are spreading at a very vigorous rate, in terms of both the number of visitors they attract (the vast majority of whom are usually school students) and their contribution to raising the level of public awareness about techno-scientific issues. For example, in Greece, two of the most prominent science centres (Technical Museum of Thessaloniki and The Environmental Education Centre Gaia) between them attract around 180.000 visitors per year, of whom around 70-90% are school students.

Thus, the combination of the dynamic spreading of science centres together with the potential usefulness of these institutions in promoting the investigative and experimental nature of the corresponding school subjects leads to the need for further research about the pedagogical presuppositions and the implications on their use as teaching resources.

During the last two decades, a considerable amount of research has been conducted on the issue of science centres. This body of research can be organised into three prevailing strands. The first strand focuses on the cognitive (Falk and Dierking, 1992; Beiers and McRobbie, 1992; Crane, Nicholson, Chen and Bitgood, 1994) and affective impact (Dierking and Falk, 1994; Tuckey, 1992; Wellington, 1989) of the science centres on students. The second strand concerns the analysis of the exhibits' design (Alt and Shaw, 1984; Borun, Massey and Lutter, 1993; Perry, 1993; Screven, 1990). Finally, the third strand brings highlights the relationship between the design characteristics of the exhibits and the learning outcomes (both cognitive and attitudinal ones) (Boisvert and Slez, 1995; Seagram, Patten and Lockett, 1993).

This study is situated in the second strand and aims to analyze the pedagogical implications of the exhibits' design in a science centre. This kind of analysis is very important for a science centre since the style of the exhibits' presentation deeply affects the kinds of thinking engaged in by visitors (McManus, 1989). The term design refers to 'the uses of semiotic resources, in all semiotic modes and combinations of semiotic modes' (Kress and van Leeuewen, 2001). In this sense, a science centre is treated as a 'text' in which a multiplicity of representational modes interweave in order to facilitate a specific type of techno-scientific discourse.

In order to analyze a science centres' exhibits in terms of their pedagogical implications, we use the theoretical notions of *classification* (Bernstein, 1996), *formality* (Halliday, 1996) and *framing* (Bernstein, 1996).

More particularly, 'classification' determines the epistemological relationship between knowledge categories (Bernstein, 1996). In particular, the categories we examine are the specialized 'techno-scientific knowledge' and the 'everyday knowledge'. The exhibits promote strong classification when they portray techno-scientific knowledge as epistemologically distinct from the everyday knowledge. On the contrary, they promote weak classification when they present these two types of knowledge as blurred.

'Formality' corresponds to the degree of abstraction, elaboration and specialization of the expressive codes employed. Low formality corresponds to codes resembling the vernacular ways of expression or approaching the realistic appearance of things. High formality corresponds to specialized codes that define reality in terms of abstractions and deeper regularities (Halliday, 1996; Kress and

van Leeuwen, 1996). The notions of classification and formality are used to describe the access allowed by the exhibits into the specialized techno-scientific knowledge.

Finally, 'framing' refers to the locus of control over the communication established by the exhibits (Bernstein, 1996). In other words, framing regulates the socio pedagogic relations within the context of a science centre. Strong framing implies that the visitor is deprived of any control over the ways he/she will interact with the exhibits; weak framing implies that the visitor is offered a wide range of options for accessing the science exhibit. The notion of framing can be conceptually further elaborated by referring to the dimensions of: a) the power (hierarchical) relationships implied between the exhibits and the visitor, b) the control of the conditions for the visitors' involvement with each individual exhibit and c) the control of the conditions under which visitors' access the various parts of a science centre (degree of linearity of a science centre). Therefore, strong framing means that the exhibits socially disempower visitors, their design discourages involvement and, also, that the science centre as a 'text' does not allow multiple paths for its 'reading'. On the contrary, weak framing means that the exhibits' design creates a feeling of social equity or even places the visitors in a position of superiority, encourages involvement and allows for multiple routes of access.

The above definitions of the notions of classification, formality and framing, show that when considered in combination they correspond to the broader issue of students' access to the pedagogic process. This kind of access is related to the students' potential to share either the specialized content delivered (classification) or the specialized codes employed (formality) as well as to participate in the determination of the rules that organize learning as a social process.

All representational modes employed in a science centre contribute (perhaps not with equal weighting) to the modulation of the levels of classification, formality and framing and hence together determine its pedagogical implications. The representational modes examined here are written language, formatting and layout of written text, two-dimensional and three-dimensional still representations and lighting. Of course more representational modes such as sound or moving images could also be found in the context of a science centre. In this paper, we decided to restrict our analysis to these four representational modes, even though we are fully aware of the need to extend our analysis in the future.

In the next section, we will present the way the notions of classification, formality and framing become operational for each of the aforementioned modes.

### The analysis grid

*Written language*

*Classification*

In the written texts of a science centre, the measure of classification is taken to be the density of the pieces of specialized techno-scientific factual information (number of pieces of information/total number of words) in each text. By the term 'pieces of specialized techno-scientific factual information' we mean definitions, explanations, qualitative and quantitative statements; e.g. the statement 'Alpha Centauri is four light years away from Earth' counts as one piece of techno-scientific information. High density implies strong classification whereas low density implies weak classification.

In Table 2, we present the way written language modulates the level of classification promoted by the exhibits of a science centre.

*TABLE 2*: *Modulation of classification by written language*

| Marker of classification | Strong classification | Weak classification |
|---|---|---|
| Techno-scientific factual informational density (no of factual pieces of information per no of words in the text) | High density | Low density |

*Formality*

Science uses a specialized linguistic code. The basic realizations of the specialized character of the techno-scientific linguistic code (formality) are the following: a) specialized terminology and notation, b) nominalizations, c) syntactic complexity and d) the use of passive voice (Halliday and Martin, 1996). These features will be treated as indicators of the level of formality of the written language of text as shown in Table 3.

*Framing*

The interpersonal/affective functions of written language are realized by specific grammatological features. In particular, the power (hierarchical) relationships are linguistically realized by the type of sentences used. A sentence can be: (a) imperative, (b) interrogative, or (c) declarative. The imperatives denote

*TABLE 3: Modulation of formality by written language*

| Formality markers | High Formality | Low Formality |
| --- | --- | --- |
| Terminology | Presence of specialized notation and terminology | Absence of specialized notation and terminology |
| Nominalizations | Prevalence of nominal groups consisting of more than two nouns | Prevalence of single nouns |
| Syntactic complexity | Prevalence of hypo-taxis (subordination) | Prevalence of parataxis (coordination) |
| Use of passive voice | Prevalence of verbs in passive voice | Prevalence of verbs in active voice |

a clear authority of the 'implied author' and hence, in this case, the framing is strong. The interrogatives denote that the 'implied author' still exerts control over the communicative process by selecting what will be asked, however, in this case, the control is moderated by the fact that the reader can have options in answering a question that can take multiple appropriate answers. Hence, the interrogatives can also be considered as signifying strong framing. Finally, in the declaratives the authority of the 'implied author' might still be present but is not as obvious and so the framing is weak.

Furthermore, the degree of the readers' involvement established by a text, is linguistically realized by the person of the verbs in it. In specific:

(a) The *first singular person* (I) represents exclusively the 'implied author'. This person is rarely met in the techno-scientific texts.

(b) The *second singular person* (You) represents the visitor. This person makes the rules of communication explicit and hence it tends to define clearly the conditions of the visitors' participation in the communication process and therefore the framing is strong.

(c) The *first plural person* (We) represents various situations. The 'We' can be regarded as meaning 'Me and You' but also as meaning 'Myself and others but not you'. Therefore, this person defines the conditions of the visitor's participation in an ambiquous way. Framing is again considered as strong.

(d) The *second plural person* (You) represents the visitor again who in this case is addressed as if he/she belongs to a broader social group and framing is considered as strong.

(e) The *third singular or plural person* (He/She/It, They) signifies that what matters is the content of the text and not the communicating agents. Therefore, framing is weak.

In Table 4, we summarize the way the various linguistic indicators modulate the level of framing.

*TABLE 4: Modulation of framing by written language*

| Framing markers | Strong Framing | Weak Framing |
| --- | --- | --- |
| Type of sentence | Imperatives, Interrogatives | Declaratives |
| Person of the verbs | Prevalence of the second singular, first plural and second plural persons | Prevalence of third singular or plural person. |

*Formatting and layout of the written text*

The formality of a written text is based on both the formality of its language (Halliday, 1996) and its formatting and layout (Kress and van Leeuwen, 2001). We will focus on the text properties that contribute to the formality of a written text at the level of its material appearance. These properties refer to the individual writing characters, the lines of text or to the appearance of the text as a whole (see Table 5).

The formality of a text increases the more uniform its writing characters and lines are and the less it deviates from a typical appearance, at least, as this has been culturally consolidated in the western literate tradition (e.g. characters of uniform colour, horizontal lines with uniform spacing, text with orthogonal shape, etc). In Table 5, we present the way the individual elements contribute to the formatting and layout of a text and so can modulate its overall formality.

*TABLE 5: Modulation of a texts' formality by the elements that determine its formatting and layout*

| Texts' properties | High Formality | Low Formality |
| --- | --- | --- |
| Individual writing characters: Size, Colour, Inclination, Font | - Uniformity across the whole text | - Non uniformity across the whole text |
| Lines of the text: | - Horizontal lines | - Non horizontal lines |
| Size, Colour, Inclination, Shape, Spacing | - Uniformity with regard to the rest of the properties | - Non uniformity with regard to the rest of the properties |
| Text as a whole: | - Orthogonal shape | - Non orthogonal shape |
| Shape, Inclination | - Horizontal inclination | - Non horizontal inclination |

*Two-dimensional and three-dimensional representations*

(a)    Classification (content specialization)

The two-dimensional and the three dimensional representations contribute to the level of classification and hence to the degree of the content specialization of the scientific knowledge projected by a science centre. Specifically the content specialization promoted by the two and three-dimensional representations is determined by:

a)    The kind of represented agents
b)    The form, and
c)    The function of each representation.

As the ontological distance between the represented entities and the entities of the everyday world increases so does the level of classification (e.g. a model of an atom has a large ontological distance with the entities of the everyday world and hence contributes to increased classification). Furthermore, as far as their form is concerned, the representations are distinguished into *conventional*, *hybrids* and *realistic* ones (Koulaidis, Dimopoulos, Sklaveniti and Christidou, 2002). All representations that represent reality in a codified way are considered as conventional. These representations are constructed according to the techno-scientific conventions and are usually graphs, maps, flow-charts, molecular structures and diagrams. Hybrids are usually conventional representations with added realistic features. Finally, all representations that exhibit reality according to visual perception are considered as realistic.

In relation to their function, the representations are divided into classificational, analytical, narrative and metaphorical (Kress and Van Leeuwen, 1996). Classificational representations are those that exhibit the type of relationships between the represented entities or, in other words, a taxonomy. Narrative representations are those that represent 'unfolding actions and events, processes of change and transitory spatial arrangements' (Kress and Van Leeuwen, 1996, p.56). In this kind of representations, the represented action is visualized by a vector, either shown explicitly or implied. Analytical representations are those that focus on the relations between the 'objects' of representation in terms of a part-whole structure. The parts of the whole may be labeled or it may be left up to the viewer to do this.  Finally, metaphorical representations are those that 'connote or symbolise meanings and values over and above what they literally represent' (Kress and Van Leeuwen, 1996, p.45). The represented participants in these images are conventionally associated with specific cultural symbols.

In Table 6, we present the way that all these elements of the two and three-dimensional representations modulate the level of classification.

*TABLE 6: Classification modulation by two and three-dimensional representations*

| Representational characteristics | Strong classification | Weak classification |
|---|---|---|
| Represented entities | Entities characterized by large ontological distance from the entities of the everyday world. | Entities characterized by small ontological distance from the entities of the everyday world. |
| Form | Conventional representation or hybrid | Realistic representation |
| Function | Classificational, Analytical, Narrative | Metaphorical |

(b)  Formality (codes' specialization)

The two and three-dimensional representations contribute also to the level of the exhibits' abstraction and hence to the level of their formality. The more an image represents the deeper 'essence' of what it depicts by downgrading the superficial variability of the external features, the higher is its formality.  This is accomplished by reduced articulation. Hence, low formality, corresponds to representations very close to realism while high formality corresponds to techno-scientific realism that defines reality in terms of what things are like generically or regularly (Kress and van Leeuwen, 1996).

The formality of the representations can be estimated using relevant indicators. These indicators record particular constitutive elements of the representations that contribute to their level of abstraction (degree of articulation). The markers used to evaluate the formality of the two-dimensional representations are: the presence of *elements of the techno-scientific code* (geometrical shapes, vectors, etc), *colour differentiation*, *colour modulation*, and the *degree of articulation of their background*.

The corresponding indicators for evaluating the formality of the three-dimensional representations are all those used for the two dimensional ones except the degree of articulation of their background, plus the *part of the three-dimensional objects represented* and their *texture*.

For example, a three-dimensional representation of a globe, whose surface appears in relief, without built-in elements of the techno-scientific code and

characterized by the use of multiplicity of colours and colour shades (e.g. deep blue for the points of large oceanic depth) can be considered as a three-dimensional representation of low formality. On the contrary, a globe appearing in half (as if it was shown from the moon), monochromatic, with a flat surface and with elements of the techno-scientific code added on (e.g. arrows representing the oceanic draughts) is characterized by high formality.

*TABLE 7: Modulation of formality by two and three-dimensional representations*

| Representational characteristics | High Formality | Low Formality |
|---|---|---|
| Elements of the techno-scientific code | Existent | Non-existent |
| Colour differentation | One or two colours | Three or more colours |
| Colour modulation | No shades | More than one shades |
| Contextualization1 | Monochromatic background or absence on any background | Background with more than one colours |
| Part of the object represented[2] | Partial representation | Full representation |
| Texture[2] | Flat surface | Relief surface |

1. Only for two-dimensional representations.
2. Only for three-dimensional representations.

(c) Framing

Finally, the two and three-dimensional representations tend to contribute to the regulation of the interpersonal/affective relationships between the exhibits and the visitors. Specifically, the element of the two-dimensional representations that contributes to the formulation of the power (hierarchical) relationships between the exhibits and the visitors is the *vertical angle of shot*. An image shown from a low angle depicts a relationship in which the content of the image has power over the viewer and hence the framing is strong. If an image is shown either at eye-level or from a high angle, this depicts a relationship in which the image has equal or less power in relation to the viewer and hence the framing is weak. For the case of the three-dimensional representations the corresponding characteristics are the *exhibits' size* and the *vertical angle of view*.

Furthermore, the degree of a visitor's involvement with what is represented in the images as a measure of his/her potential to participate in the communication

process is visually realized by the *distance* and *the horizontal angle of shot*. In particular, the distance of shot regulates the level of intimacy that is possible to be established between what is represented and the visitor and takes the values of close, medium and distant shot, which correspond to an intimate/personal, social and impersonal relationship respectively.

The horizontal angle of shot signifies the degree of involvement that the visitor can have with the represented agents and takes the values of frontal and oblique angle. 'The difference between the frontal and the oblique angle is the difference between familiarity and detachment' (Kress and Van Leeuwen, 1996, p.143). The corresponding characteristics for the case of the three-dimensional representations are the *minimum distance* that a visitor can *approach* each representation and the *horizontal angle of view*[1].

For example, a three-dimensional representation of a celestial body that is large in size, can be viewed from a high and oblique angle and which cannot be touched, tends to create a feeling of diminishment and alienation and hence promotes strong framing. On the contrary, a three-dimensional representation of a molecular model, which can be viewed at the eye-level and frontally and which can also be manipulated by a visitor tends to create a feeling of familiarity, calls for involvement and hence promotes weak framing.

In Table 8, all the individual characteristics that modulate the level of framing for the two and three-dimensional representations are shown.

*TABLE 8: Modulation of framing by two and three-dimensional representations*

| Representational characteristics (Power relationships) | Strong framing | Weak framing |
|---|---|---|
| Vertical angle of shot[1] | Low angle | Eye-level or high angle |
| Vertical angle of view[2] | Viewed from below | Viewed at eye-level or from above |
| Size[2] | Large | Human like size or less |
| **Representational characteristics (Visitors' involvement)** | **Strong framing** | **Weak framing** |
| Horizontal angle of shot[1] | Oblique | Frontal |
| Horizontal angle of view[2] | Side view | Frontal view |
| Minimum distance of approach[2] | The visitor can only see but not manipulate the exhibit | The visitor can manipulate the exhibit |

1.  Only for two-dimensional representations.
2.  Only for the three-dimensional representations.

*Lighting*

Lighting in a science centre can modulate both the level of abstraction of the exhibits, and hence the level of the exhibits' formality, and the range of options available to the visitors, and hence the level of framing.

(a) Formality

Abstraction is again accomplished by reduced articulation. Thus, the more elements of lighting contribute to the realistic appearance of the exhibits, the lower the formality. These elements are: the *realism of the colours* of lighting, the *colour differentiation* as well as the *degree of directionality* of lighting.

The more realistic and differentiated the colours of lighting are and the more diffuse the light that falls on the exhibits is the lower the formality. On the contrary, a well known technique often employed in science fiction films is the use of unrealistic and usually monochromatic lighting which takes the form of very narrowly focused light beams. This technique creates a futuristic and technocratic atmosphere signifies high levels of formality. An example of this technique is the intense blue lighting emitted in the form of narrow light beams in the descent of the aliens' spacecraft in Spielberg's film *Close Encounters of the Third Type*.

In Table 9, we present all the lighting properties that modulate the level of the exhibits' formality.

*TABLE 9: Modulation of formality by lighting*

| Representational characteristics | High Formality | Low Formality |
| --- | --- | --- |
| Degree of colours realism | Unrealistic colours | Realistic colours |
| Colour differentation | One or two colours | Three or more colours |
| Degree of directionality | Focused light beams | Diffuse lighting |

(b) Framing

Lighting can also modulate the level of framing projected by a science centre. The lighting property that plays a crucial role in determining the level of framing is the intensity of illumination of an exhibit in relation to the corresponding intensity of the surrounding exhibits. In particular, when the illumination of an exhibit is more intense in comparison to the illumination of its surroundings then it becomes more prominent and so in an implicit way the visitor is forced to draw

his/her attention to it. In this way, lighting reduces the visitor's control and hence leads to strong framing. On the contrary, when an exhibit is not more intensely illuminated with respect to its surroundings, there is no implied hint to the visitor to draw his/her attention to it and hence the framing is weak.

In Table 10 below, we present the way lighting can modulate the level of framing.

*TABLE 10: Modulation of framing by lighting*

| Lighting property | Strong framing | Weak framing |
| --- | --- | --- |
| Intensity of lighting with respect to the surroundings | More intense lighting with respect to the surroundings | Uniform lighting everywhere |

*Degree of linearity of the science centre*

The presentation of all the exhibits in a science centre as a whole constitutes a separate representational system carrying its own semiotic meaning. The prevailing feature of this composition that will be examined here is the degree of its linearity.

The degree of linearity reveals the strength of each exhibit's connections to the other exhibits. This strength can be estimated by the existence of signs of explicit or implicit (e.g. morphological features such as common colour, background or lighting) reference to other exhibits, the proximity between the exhibits, as well as the presence of connective elements, such as the numbering of different parts of an exhibit or of a group of exhibits. For a specific exhibit, a low linearity grade means that it can be accessed in a rather independent way without the need to refer to any other exhibit. A high linearity grade means that an exhibit is tightly linked to one or more other exhibits and so the visit must follow a prescribed path in his/her tour around the science centre. As a result, the more a science centre contains exhibits with a high linearity grade, the more the visitors have to comply with a specific path of navigation during their visit and the more the exhibition tends to be characterized as linear. In this case, the visitor has restricted control and hence framing is strong. On the contrary, the less linear a science centre is, the more a visitor is allowed to navigate through it in a multiplicity of ways and hence the promoted framing is weak.

In summary, we present in Table 11 the functions of all the representational systems analyzed here. All these systems cooperate so as to create a coherent

discursive ensemble that tends to shape the pedagogical meaning of a science centre. The messages are either explicitly or implicitly communicated to a visitor through a process called synesthaisia, meaning that all his/her senses take part in their reception (Kress and van Leeuwen, 2001).

*TABLE 11: Functions of all the representational systems employed in a science centre*

| Representational system | Classification | Formality | Framing |
|---|---|---|---|
| Written language | • | • | • |
| Text formatting and layout | | • | |
| Two dimensional representations | • | • | • |
| Three dimentional representations | • | • | • |
| Lighting | | • | • |
| Degree of linearity | | | • |

## The sample

The grid presented above was used to analyze one thematic units of the 'Gaia' science centre[2]. 'Gaia' is an Environmental Research and Educational Centre, co-funded by the EU Cohesion Fund and the Greek Ministry of the Environment. It operates since June 2001 in Kifissia, Athens, Greece and its main objectives are:

• to promote a new approach to environmental education, supported by the use of new technologies
• to promote research actions in a wide range of environmental issues, and
• to act as a documentation centre for publication on environmental topics.

The exhibition of 'Gaia' was designed with the collaboration of experts from the London Natural History Museum. It covers a surface area of about 2000 m$^2$ and it consists of three main parts. The first part is a presentation of the Earth's natural systems (thematic units 1-6). The second part is a summary of human inventiveness in the use of the Earth's natural resources (thematic unit 7). In the third part, visitors are introduced to environment-friendly ways of serving human needs (thematic units 8-14).

The thematic unit examined here, belongs to the first part of the 'Gaia' exhibition and is titled 'Structure and Function of the Earth.' It consists of four groups of exhibits, which focus on the issue of solar radiation and the Earth's atmosphere. These groups are as follows:

a) 'Sun, the Earth's Feeder': This group of exhibits focuses on the way the solar radiation interacts with the Earth's atmosphere. The Sun and its radiation are represented via intense yellow lighting. There are also three accompanying texts and one three-dimensional model of solar radiation. This three-dimensional representation corresponds to a transparent tube in the shape of a sinusoidal curve with small light bulbs inside.

b) 'Types of Solar Beams': This group presents the spectroscopic analysis of solar radiation. Specifically, it consists of seven screens, each presenting one text concerning a different part of the solar spectrum (gamma rays, X-rays, ultraviolet rays, visible light, infrared radiation, microwaves and radio waves). The press of a button activates each screen independently.

c) 'Earth and the Atmospheric Layers': This group concentrates on the structure of the Earth's atmosphere. It consists of a three-dimensional model of a quarter of the Earth from the edge of which start four concentric two-dimensional cycles each corresponding to one of the four layers of the Earth's atmosphere. The group also contains an introductory text and one text for each of the four atmospheric layers.

d) 'Atmosphere: the Earth's Shelter': This group shows the protective role of the atmosphere for the maintenance of life on the Earth's surface. In particular, it contains a synthesis of three texts and two two-dimensional representations presenting the consequences of the use of aerosols for the atmosphere – such as the ozone hole.

In total eighteen texts, two two-dimensional and two three-dimensional representations were analysed. Additionally, the lighting of all four of the groups of exhibits as well as the degree of linearity of the thematic units were also analysed. In particular, these representational modes were analysed in terms of their contribution to the level of content specialization (classification), the codes' elaboration (formality), and their interpersonal/affective function (framing). The results will allow us to draw some conclusions on the pedagogical functioning of science centres, particularly in respect to the issue of promoting an exploratory teaching of science.

## Results

### *Classification*

As is evident from Table 11, the representational modes that contribute to the content specialization (classification) of a science centre are the written language and the two and three-dimensional representations.

The written language of the texts examined, promotes high levels of classification and hence presents the content of techno-scientific knowledge as a specialized and quite distinct form, as compared to every-day, commonsense knowledge. We do not mean to imply that there is no reference to the every-day experiential world of the visitors but that this is mainly done by providing examples of the way the specialized techno-scientific knowledge is applied influencing our everyday lives. More particularly, 13 out of the 18 texts analyzed contain more than one piece of factual information per ten words. It must be noted though that given the fact that these texts are all very short (mean number of words per text=24.3, s.d=13.8), on average, Gaia's texts do not usually provide more than three pieces of factual information, hence, they do not require intense cognitive effort on the part of the visitors so as to grasp the presented techno-scientific content. A typical text usually consists of two parts. The first part presents the essential background pieces of techno-scientific factual knowledge and the second part describes the way this underpin lies behind a number of everyday applications. An example is the following:

> 'The light beams arrive at various wavelengths, which are widely recognized as colours. When all the wavelengths are seen together, light is perceived as white. When the white light is analyzed through the rain-drops, it forms the well-known rainbow. Plants need light to produce food, while animals need light to see.'

The trend for strong classification is further reinforced by the form and function of the two-dimensional and three dimensional representations. In particular, as far as their form is concerned, the two three-dimensional representations and the one two-dimensional representation are *hybrids,* whereas, with respect to their function, the two two-dimensional representations are *analytical* and the two three-dimensional representations are *narrative* ones.

*Formality*

The level of formality of a science centre's exhibits is determined by all the representational systems presented here except the degree of linearity. In particular, the written language of the eighteen texts is characterized by low formality in all of the cases. Additionally, the texts' formatting and layout contributes also to the low levels of formality (in 15 out of the 18 texts). On the contrary, the two and three-dimensional representations (in three out of four cases) are characterized by high levels of formality. Finally, low levels of formality characterize lighting in all cases.

All the previous results converge to a prevailing image according to which, Gaia's exhibits are characterized by low levels of formality. This means that most of the representational modes except of the two and three-dimensional representations present the content of the exhibits using codes close to the vernacular and realistic ways of expression.

*Framing*

As far as the social distribution of the control over the communicative process established in the context of the Gaia science centre, the results from all the representational modes lead to the conclusion that the visitors are allowed a great deal of autonomy in accessing the exhibits and hence are treated as socially equal partners who are highly motivated to engage with them.

More particularly, the linguistic code of all eighteen texts provokes a weak framing by making extensive use of declarative sentences and by using verbs in the third singular or plural person. In this way, the communicating agents seem to withdraw from the scene and greater emphasis is placed on the content to be communicated. The two two-dimensional and two three-dimensional representations also promote the same levels of framing, respectively. Finally, the weak framing is further reinforced by the low levels of linearity within each of the four groups of exhibits. In particular, in three of these four groups of exhibits the degree of internal linearity is low allowing the visitors to access each exhibit in a rather independent way and only in one of them the structure imposes on the visitors a linear way of access.

## Discussion

The analysis of a small but representative part of a typical science centre along the dimensions of classification, formality and framing revealed the way the visitors are socially constructed as learning subjects within the framework of similar institutions. More particularly, it was found that the design of the exhibits in the Gaia Science Centre projects an image of science as a distinct form of knowledge (strong classification) in relation to the everyday commonsense knowledge. The scientific knowledge is also presented as the key required for explaining the functioning of everyday natural phenomena and of very familiar technological devices.

On the other hand, the specialized nature of the scientific knowledge does not prevent it from being expressed in codes of low formality. Such codes acting at a superficial level usually pose barriers in the understanding of the relevant subject

matter and alienate most of the students from the effort to grasp the deeper meanings of the scientific concepts (Martin and Veel, 1998). Since the expressive codes of low formality are very close to the vernacular ways of communicating and to the realistic appearances of things, the attempt is to link the specialized knowledge with the everyday experiential world not only in terms of its potential to provide explanations but also in terms of the vernacular and realistic codes employed.

With regards to the social positioning of the visitors as learners in the context of the Gaia Science Centre, we found that the design of the exhibits addresses a visitor who is highly motivated to interact with the exhibits and is also extremely autonomous in deciding his/her own learning experiences (weak framing). This model of the learner is drastically different from the model formulated within formal educational settings where the students usually remain passive while being guided in a strict predetermined way towards the acquisition of a highly structured body of knowledge.

The generated sense of self-determination and control over the projected knowledge can definitely reveal to the students the investigative, playful and exploratory nature of science and hence contribute to the change of the widely held view among students that science is a set of finalized truths that should only be learned by rote for the purpose of passing exams (Driver et al., 1996). The undertaking of full control over the communication process on the part of the learner (weak levels of framing) and the high levels of autonomy in initiating, continuing or redirecting his/her own learning is possibly the most important characteristic of the pedagogical framework of a science centre that make the experience of visiting it so unique so as to generate strong affective outcomes (McManus, 1993; Roberts, 1993; Uzzell, 1993).

The increased probability that self-directed learning can occur in a science centre is further reinforced by the fact that such institutions, by being multimodal, can cater for different learning preferences. The personification of the learning experience due to the multimodality of a science centre is based on the theory of multiple intelligences (Gardner, 1993). According to this theory, a person can exhibit seven types of intelligences, which are the linguistic, the logico-mathematical, the spatial, the musical, the bodily kinaesthetic, the interpersonal and the intrapersonal intelligences.

The employment of diverse representational modes (e.g. written text, lighting, visual representations, etc) in science centres can help the students to make meaning of the conceptual framework of science activating a wider range of their intelligences than is usually possible through the use of more conventional teaching resources (e.g. textbooks).

In summary, we can say that the science centre regulates a specific image of science as a knowledge system and accordingly a certain type of visitors as science

learners. More particularly, science is presented, in piece meal format, as a specialized body of knowledge (strong classification) which can provide the basis for the explanation of the everyday world, expressed in vernacular and realistic codes (low formality) and consisting of elements that can be discovered through active personal involvement and free exploration. The corresponding image of the science learner that emerges, is a person who each time needs to grasp few essentials of the techno-scientific content in order to be able to explain its natural and technological environment, without needing to be tangled up with the complexities of the specialized and abstract techno-scientific conventional expressive systems, but, on the other hand, definitely needing to develop an exploratory and independent approach towards science learning.

This emerging picture could prove extremely useful from a pedagogical point of view, since it combines the communicative features found in another study (Koulaidis, Dimopoulos, Sklaveniti, 2002) of conventional educational resources (e.g. textbooks) of both the primary (strong classification, low formality, strong framing) and the lower secondary level (strong classification, high formality and weak framing) as well as of popularized techno-scientific material (short texts requiring limited attention span, lively presentation through the use of multimodal resources and links with everyday applications). The combination of various, also features found in other communicative contexts (school and wider culture), makes the science centre a 'text' that is easily adaptive to other texts already encountered by the students.

Furthermore, the identification of the science centre's special discursive characteristics in relation to the corresponding characteristics of other learning environments demonstrates the way that it could be used for pedagogical interventions, so as to change both the students' perception of the nature of science and of themselves as learning subjects tied to action agendas that require little initiative.

In conclusion, we would like to note that the grid used for the analysis of the Gaia Science Centre, could also be used for analyzing other multimodal texts employed as teaching resources in science education (e.g. CDRoms, WWW sites, Video, etc). The analysis of all these educational resources along the common dimensions of classification, formality and framing could reveal underlying pedagogical principles that determine the construction of their techno-scientific messages and, hence, would allow the use of these resources within the formal educational system in a manner that is more theoretically informed, than is usually the case.

## Notes

1. An exhibit can of course be both approached to varying minimum distances and viewed at different horizontal angles. In this particular case though, what is meant is whether the exhibits arrangement privilege any specific distance of approach (e.g. barrier in front of an exhibit, or exhibit in a glass case) or any specific angle of view (e.g. frontal view, side view).

2. The Gaia science centre consists of fourteen thematic units titled: 1. With Nature, 2. Our world today, 3. Earth's Uniqueness in the Universe, 4. Structure and Function of the Earth, 5/6. Natural Equilibrium, 7. Making use of the Earth, 8. Meeting the challenge, 9. The energy challenge, 10. The transportation challenge, 11. The natural resources challenge, 12. The water challenge, 13. Food challenge and 14.With Nature.

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# GLOBAL SCIENCE LITERACY: DEFINITION, NEEDS ASSESSMENT AND CONCERNS FOR CYPRUS

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**Abstract** – *Global Science Literacy has as its goals to stimulate an interest in science, represent modern technological goals of science, develop international understanding, relate science to social needs, and develop thinking and problem-solving skills for the 21st Century. Such an approach is proposed as viable on an international basis for conceptual strength in integrated science courses. Assessment of GSL's potential in Cyprus serves as an example of preparations needed and concerns to be addressed if GSL is to become the basis of the science curriculum. Toward this end, a survey of teachers throughout Cyprus identified teachers' priorities for environmental issues and system science concepts their students should know, the teachers' knowledge of those concepts and issues, and their current levels of teaching them. This paper will discuss the teachers' relative perceptions of local and global understandings, Earth systems science, and teacher education issues involved in fostering Global Science Literacy.*

## Introduction

*E*ducation about the environment and about the Earth systems sciences could provide information to answer important questions about some of the most relevant and pressing science-based issues of the 21st Century. The late Isaac Asimov wrote, 'Increasingly, our leaders must deal with dangers that threaten the entire world, where an understanding of those dangers and the possible solutions depends on a good grasp of science.

The ozone layer, the greenhouse effect, acid rain, questions of diet and heredity –– all require scientific literacy' (Augustine, 1998).  In a world focused on the competitive testing that compares one country to another in science achievement, cooperation among countries to raise the science literacy of all requires a non-competitive, interdisciplinary approach to the entire curriculum. Global Science Literacy begins with Earth systems education, since ESE applies all the sciences to understanding and dealing with the natural processes and human-generated hazards of modern living.

## Emerging concept of Earth Systems education

A growing number of scientists and educators are forwarding the notion that the appropriate focus for all of science in the curriculum is Earth, with its interacting components of water, land, air and life, and with its instant relevance and interest for students (Fortner and Mayer, 1998; Barstow, Geary and Yazijian, 2002). Education about the Earth system emphasizes the interdisciplinary aspects not only within science but of science with the other subjects of the curriculum as well.

System sciences in general have been characterized as operational in *levels* of organization of nature rather than in distinct categories or disciplines (Lazlo, 1995). The disciplines made great contributions over the centuries through their reduction of big ideas into their components, but 'in the twenty-first century, science will be in a position to begin putting the pieces together, in order to seek a synthetic or holistic understanding of Nature. The Earth sciences are inherently synthetic and are therefore uniquely placed to lead this development' (Alvarez, 1997). Mayer and Fortner (1995, 2002), Fortner and Mayer (1998) and colleagues at all levels of science education suggest that the concept of the Earth as a system could be central to science curricula worldwide, replacing the current disciplinary approach with an approach that recognizes the importance of concepts from all the sciences. In turn, Earth systems education can form the basis of global science literacy.

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### Framework of understandings for Earth Systems Education

1. Earth is unique, a planet of rare beauty and great value.
2. Human activities, collective and individual, conscious and inadvertent, affect Earth systems.
3. The development of scientific thinking and technology increases our ability to understand and utilize Earth and space.
4. The Earth system is composed of the interacting subsystems of water, land, ice, air and life.
5. Earth is more than 4 billion years old, and its subsystems are continually evolving.
6. Earth is a small subsystem of a Solar system within the vast and ancient universe.
7. There are many people with careers and interests that involve study of Earth's origin, processes, and evolution.

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[Expanded version available at http://earthsys.ag.ohio-state.edu]

The key elements of Earth systems education are contained in a simple Framework of Understandings developed by scientists, science educators, and classroom teachers. These elements are also the basis of what many feel is important in global science literacy as well as much of what is traditionally considered the realm of environmental education. The scientific thinking and decision-making aspects of Earth systems education are appropriate bases for approaching environmental issues rationally.

The urgency of information about environmental systems, which justifies the position of values and stewardship as the first two Understandings, was noted by Dr. Jane Lubchenco (1998) in her presidential address to the American Association for the Advancement of Science: 'We can no longer afford to have the environment be accorded marginal status on our agendas. The environment is not a marginal issue, it is the issue of the future and the future is here now.' Not only do studies of the environment offer rich experiences with real data, and the need to consult many disciplines in search of answers, but they also provide a reason for doing science and a means of introducing the value of good stewardship of resources.

## Needs assessment for ESE/GSL

Are educators in Mediterranean countries aware of the importance of Earth systems concepts and the value of environmental studies for the development of global science literacy? The TIMSS-III data show only one Mediterranean country (Italy) above the mean score for Grade 8 measures and six below the mean (Martin *et al.*, 1999). However the test bank includes an overwhelming proportion of items testing knowledge of concepts in single disciplines. Cyprus students did best on environmental topics and had lowest scores on Earth science topics within their own country's sample, but internationally the country scored below the mean in both areas. Traditional competitive test scores may not be a good indicator of the development of global science literacy, but at this point in science education development they are serving to alert countries of needs they might have.

An administratively simple teacher perception survey offers a look at how an educational system may come to realize its own needs and preparation for environmental and/or Earth systems education. The method has been used successfully in identifying needs for Great Lakes education in North America (Fortner and Corney, 2002), and to find discrepancies between teachers' knowledge and priorities for teaching (Fortner and Meyer, 2000). The technique now offers a first step in assessing a region's potential interest and preparation for global science literacy. First a number of topics are identified for their relevance

to GSL goals. These should include some global environmental issues and some local ones, as well as topics or concepts representing the seven Earth Systems Understandings. Three questions are asked about each selected topic:

• How important is it for students in your school to know about the topic?
• How much do you know about the topic?
• To what extent are you currently teaching about the topic?

After they rate each of the topic areas three ways, the responding teachers are invited to provide reasons for not teaching some of the topics, and to identify the topics about which they wish to know more. They suggest their preferred mode of acquiring new science information for teaching, and conclude by providing some demographic information about themselves and their teaching situation.

The nature of the three key questions allows education professionals to examine whether the goals of GSL would be acceptable in the classroom and how much teacher preparation would be needed to implement it. Responses from teachers at different grade levels can indicate where the key topics might fit best based on teacher preparation, and how the topics might be sequenced for building learning through successively more complex and global understandings.

## The Cyprus example

In Cyprus there is little precedent for integrating the sciences, even though the gymnasium level (middle school) curriculum was initially organized to foster multidisciplinary science experiences each year (Ministry, 1996). An exception currently being pilot tested is the offering of Natural Science in selected *lycaea* (high schools). TIMSS performance by Cypriot students indicates a lack of preparation in the area of physical geography and on other items that are somewhat representative of Earth systems content. The assumption is that implementation of GSL as the science curriculum goal, with ESE as the mechanism and environmental issues as an integrative medium, would foster greater science knowledge because of the relevance of topics and interrelationships of information.

Objectives of the Cyprus study were to answer key questions:

1) What priority do teachers place on certain Earth systems and environmental topics for students in their schools to know?
2) How do teachers assess their own knowledge levels about these topics?

3) To what extent are teachers currently teaching the topics?
4) What differences exist between primary and secondary teachers with regard to their priorities for, knowledge and teaching of the topics?
5) In what forms do teachers prefer to receive information and curriculum materials?


## Methods

A survey was developed listing ten environmental issues identified by a focus group of Cyprus teachers, and a final two added by the authors based on observation of actual problems or potential issues faced by the island nation. The list of environmental issues salient for the focus group of teachers included the first ten items below. Soil loss and imported species were added based on evidence of their existence in the country.

| | |
|---|---|
| Ozone depletion | Global warming |
| Trash disposal | Tourism pressure |
| Air pollution | Acid rain |
| Extinctions of living things | Sea pollution |
| Oil spills | Access to fresh drinking water |
| Imported species | Loss of soils |

Another ten topics were assembled based on the Framework of Understandings to represent Earth systems content that curricula might include. Understanding #2 was covered in the environmental issues section, and geography and ecology of Cyprus were included because ESE uses the local environment for developing relevance of more global themes. The topics thus included in the ESE section, and the Understandings from which they were inferred, consisted of

| | |
|---|---|
| Arts in science teaching (ESU #1) | Uses of technology for science (#3) |
| Interactions of air, water, land, life (#4) | Processes of science (#3) |
| Change over periods of time (#5) | Energy flow in nature (#6) |
| Careers in science (#7) | Earth's place in space (#6) |
| Ecology of Cyprus (local relevance) | Geography of Cyprus (local relevance) |

The survey was administered to two groups of teachers:

1) Secondary science teachers at a required briefing held by the Ministry of Education and Culture. Respondents were science teachers of the Gymnasium

level (grades 7-9) and the Lyceum level (grades 10-12), in the four regions of the Republic of Cyprus (Fortner and Constantinou, 2000).

2) primary teachers in schools from the four Cyprus districts. Seven teachers participating in an Environmental Education course in the University of Cyprus' new graduate program for Learning in Science each gave the survey to at least 10 other primary (grades K-6) teachers in their own or other schools.

## Results

Usable surveys were received from 96 primary and 116 secondary teachers. Secondary teacher respondents included 53 males and 44 females, with an average of 18 years' teaching experience (range 3-30 years). They had bachelors' degrees in science subjects or geography, and only 9 had masters' degrees. All were teaching in public schools and 90% were from cities rather than villages of Cyprus. Among the primary teacher respondents were 19 males, 36 females and the rest not reporting gender. They had been teaching for an average of 11 years (range 1 – 33 years), and 6 had Master's degrees. Most taught in cities of Cyprus, but 26 listed villages instead. Given the non-random selection of the sample the ensuing analysis is not generalizable to other groups of teachers, but the sample size makes it a good representation of the perceptions of Cyprus teachers.

Since Understanding #2 relates to environmental topics, and the other six understandings in Earth systems education were also part of the survey, all 22 topics were analyzed as a single set. The authors acknowledge the weighting of environment in the list, but maintain that the interdisciplinary methods of ESE and the relevance it seeks make environmental studies a possible mechanism for getting all of ESE into the curriculum. Putting the 12 environmental issues together with the ten ESE topics allows the results to show the relative use of environment compared with other more general topic areas.

*Priority*

The topics selected as highest priority by the primary teachers (most important for students in their school to know) included three environmental issues and three ESE topics, in the order shown in Figure 1. The environmental issues represented one visible local issue (trash disposal, rated 3.7 out of 4), and two global issues with much local visibility (air and sea pollution, 3.7). High priority ESE topics (3.7) were Earth's place in space, a unit taught only in primary schools, and an item with obvious local relevance, ecology of Cyprus. Among secondary teachers the highest priorities were assigned to four environmental issues (ozone hole and air

pollution, both 3.9, acid rain and sea pollution, 3.7) and one ESE topic (ecology of Cyprus, 3.7). Both primary and secondary teachers named introduced species among the lowest priorities, with primary also adding careers in science, soil loss, and interactions of water, land, air and life. Secondary teachers also placed low priority on change over time and the arts in science teaching.

FIGURE 1: Priority for Cyprus students to learn about selected issues and topics for Global Science Literacy
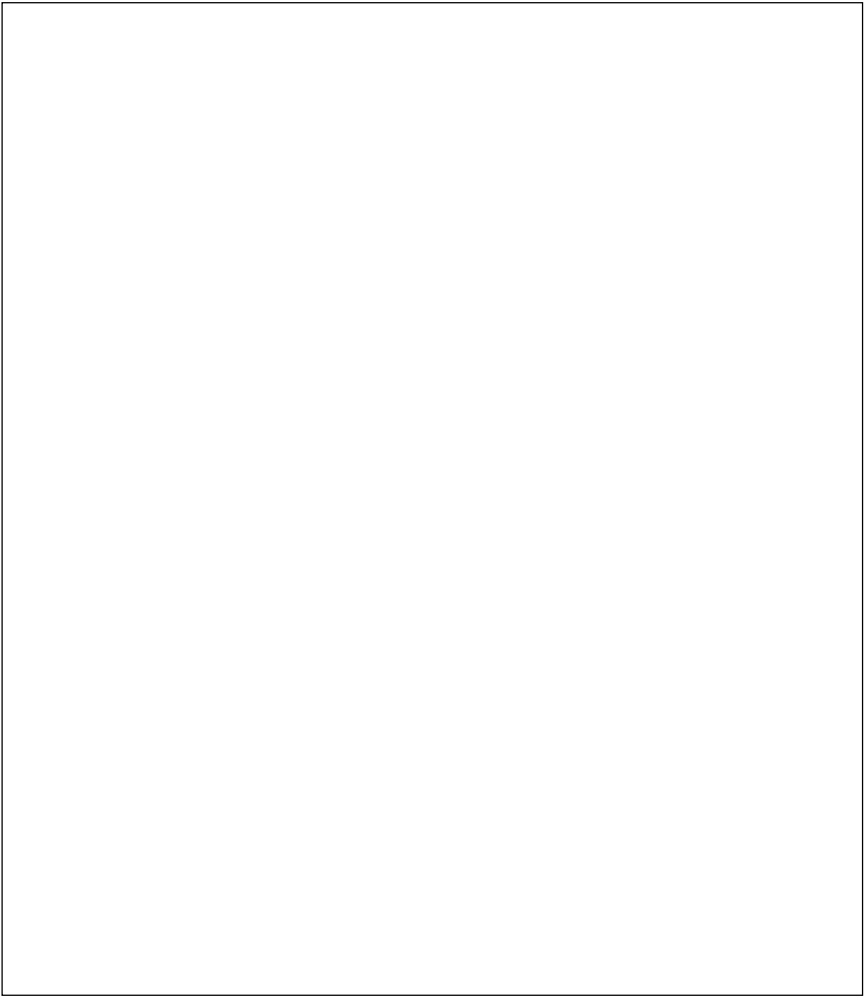
*Knowledge and teaching level*

Teachers' self-reported knowledge of the 22 topics showed additional differences by teaching level (Figure 2). Primary teachers reported knowing most about air pollution and Earth's place in space (3.2 out of 4), while secondary teachers claimed acid rain and air pollution (3.7), sea pollution and Earth's place in space (3.5) as their most knowledgeable areas. The secondary teachers report teaching most about air pollution and the primary teachers sea pollution and physical geography (3.1 and 3, moderate teaching). Level of teaching of the topics was strongly correlated to teacher knowledge (primary $r = 0.87$; secondary $r = 0.97$) as shown by the lines in Figure 2.

*FIGURE 2: Self-reported knowledge and level of teaching of issues and topics*
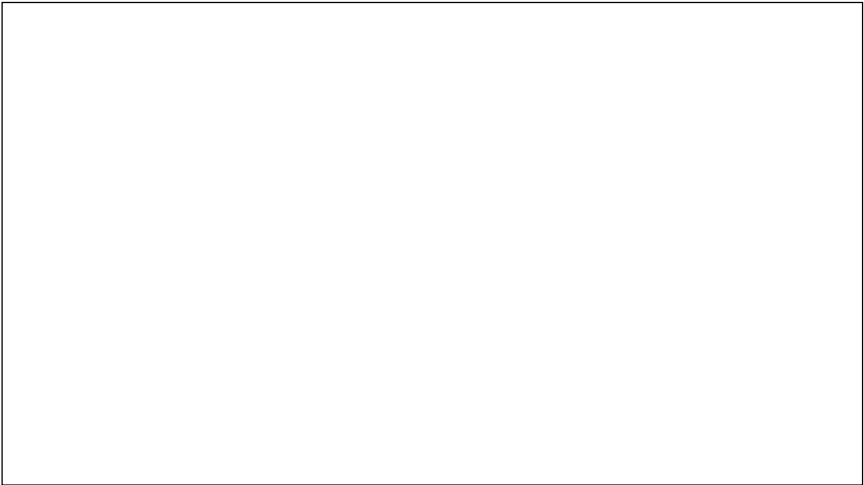


The relationships of topic priority to teachers' knowledge and teaching level were assessed for each teacher group as well. Again relationships were strong for both groups of teachers on both measures. Priority was strongly and positively related to knowledge ($r = 0.76$ for primary teachers and .83 for secondary) as well as to amount of teaching ($r = 0.73$ and 0.84, respectively). Differences between primary and secondary teachers on overall measures of topic priority, knowledge and teaching were all significant (for priority, $p < 0.05$; for knowledge and teaching, $p < 0.001$).

When asked why certain topics are not being taught, teachers responded most often that the topics were part of the responsibility of another subject area or

another grade level, or more generally they were 'not part of the curriculum.' 'It's not my job' is a legitimate reason for not doing a particular task. If it is important, however, that primary students be introduced to science careers, or that aesthetics become a way to meet certain learning styles in secondary schools, teachers are not responding to that information. 'There is not enough time' was another common reason for not including topics. Perhaps the length of the school day or contractual constraints of a strong teachers' union do not allow for additions to the curriculum that would enhance global science literacy to the extent that some of these topics are expected to do.

Where do teachers get their environmental information, and in what form would new instructional materials best be received? Primary teachers in 2002 reported getting most of their information for teaching about the environment from television, with secondary sources of workshops/classes and organizations (Figure 3). Secondary teachers in 1999 reported their information sources as specialty magazines and books, with television a third choice and workshops and classes a distant fifth.

The form of teacher education preferred by Cyprus primary teachers is a weekend workshop (30%) followed by one-day or credit workshops (16% each). Secondary teachers overwhelmingly preferred experiences bearing university

*FIGURE 3: Primary teachers' sources of environmental information*
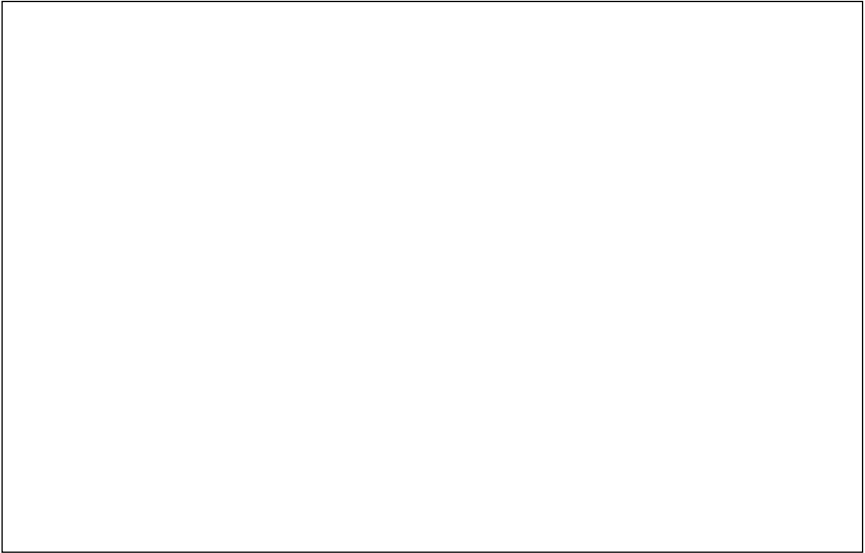
credit (55%) with one-day workshops also acceptable (18%). If environmental education materials are to be useful to them, the form for primary teachers should be lesson plans, followed by audiovisual materials and then reference materials of various kinds. Secondary teachers want audiovisual aids and textbooks or reference materials.

## Discussion

It is clear that Cyprus teachers at all K-12 levels see the set of selected topics as important for their students to learn (20 of 22 topics rated 2.7 or higher out of 4), and this alone might be used as justification for new efforts at implementation of steps toward global science literacy as exemplified by Earth systems education. Of the five topics rated most important at both levels, 3-4 were environmental issues and the remaining were the local-to-global combination of ecology of Cyprus and Earth's place in space. To continue schooling children without environmental studies is not educating them for informed global citizenship, and perhaps the teachers' ratings of issue importance are a signal that a curriculum to include the local and global environment would be accepted.

Local citizenship has an important environmental component too, but with the exception of trash disposal the local issues were rated as less important than the global ones. This result should raise some concern. While issues such as the ozone hole, air pollution, acid rain and sea pollution are all very important, they are not the kinds of issues that people see as requiring their personal commitment to the environment. It is easy to espouse learning about these issues, learning to shake our heads solemnly when confronting their global severity but continuing with the local lifestyles that contribute to them. The mass media and school textbooks with global viewpoints are probably responsible for the salience of global issues in teachers' thinking. At the same time, issues like soil loss (2.9 and 3.2 for primary and secondary, respectively) and introduced species (2.8 and 2.7), both obvious to a newcomer as issues that should be of local concern, are rated the lowest importance of the issues. Perhaps these are not seen by teachers as something that children can address personally, but they are certainly issues that have local relevance and can be seen in many examples, compared to the ozone hole and acid rain which are much more abstract and distant issues. As for the issue of trash disposal, the primary teachers found it very important but secondary teachers did not. Any early training in recycling and rubbish control is likely to go without reinforcement in later grades.

'Arts in science teaching' was a topic rated by secondary teachers as having low priority. Global education requires an holistic view, and countries such as Spain are trying to develop methods for addressing such a view through an interdisciplinary curriculum. Lillo and Lillo (2002) describe a cross-curricular approach for high school and first year university students that follows the ways ancient Greeks and Romans understood nature. According to the authors, 'The objectives for these activities are to develop positive ethical and aesthetic attitudes about the role of human beings in nature' (p. 137). Adaptation of this approach and materials could assist in meeting the Framework Understandings #1 and 2.

Two issues rated low in priority, system interaction in primary years and change over time at the secondary level, are key to Earth systems education. If students are not taught at an early age that 'everything is connected to everything else' (Commoner, 1971), it will be difficult for them to integrate science topics to answer important questions. Understanding the ecology of Cyprus, for example, one of the priority topics, requires awareness of the relationship of the hydrologic cycle and soil characteristics to the vegetation types supported at different island sites. Planting a tree for nature study will not succeed without attention to the water and soil conditions required by the selected tree species. As for change over time, a low priority for secondary, the teaching of organic evolution is key to modern biological principles, and the range of system changes becoming apparent in global climate change stands to alter not only ecology but human endeavours for the future. Adding ESE to the curriculum would assist with preparation of students for 21st Century needs and demands for decision making.

Finally the issue of introduced species, low priority for all Cyprus respondents, is a major factor in ecological change worldwide. The Great Lakes region of North America sees the introduction of several new species each year, and San Francisco Bay has over 250 exotic species now impacting its ecosystem. Nature in its normal state is in dynamic balance, and new species introductions disrupt that balance, nearly always in negative ways. Cyprus has no agricultural inspection at Customs, and people casually bring in attractive or culturally important plants from other parts of the world to decorate their island homes and gardens. One has only to look at the impact of the eucalyptus trees, brought in to dry up wetland areas, to see how successful imports can be. Even in the sea, invaders such as *Caulerpa taxifolia*, an aquarium plant apparently discarded in the western Mediterranean, are threatening the naturally diverse assemblage of sea organisms. Nowhere in the media or textbooks are such issues addressed, yet they have the potential to shape life in the Mediterranean region for centuries to come.

## Conclusion

Global science literacy is a requirement for sustainable lifestyles in the 21$^{st}$ century. A combination of knowledge, awareness, and life skills in dealing with the environment and the interacting forces of Earth is needed by all inhabitants of the planet. If school is to be part of that preparation for survival, the science curriculum is the key.

Like other Mediterranean nations Cyprus has room to build a stronger science curriculum. With this research we have identified a list of priority areas that would be acceptable in that curriculum, and the ways that teachers learn about the topics. Combinations of public mass media and targeted publications can strengthen the science knowledge of the teaching population, and the teachers clearly indicate that topics are used in the classroom in proportion to how much the teachers know.

If the providers of science teacher education and curriculum materials wish to further increase the possibilities of teachers using Earth systems topics, the research has identified modes of in-service education and instructional resources that are most desired at the primary and secondary level. Developing courses for credit, with audiovisual and reference materials for secondary teachers would best serve that group in implementing new topics in teaching. For primary teachers the new topics are best introduced through classroom activities and lesson plans available through weekend workshops.

Using this simple survey format thus provides a concise but powerful needs assessment tool and helps identify the potential for success in curriculum innovation. The importance of global science literacy warrants attention of all Mediterranean countries to whether their schools' potential for contributing to such literacy is being met. Resources exist throughout the region for addressing these needs; what crisis of environment will convince educators that the time for fostering global science literacy is now?

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# SCHOOL DIFFERENCES IN PHYSICS EXAMINATIONS FOR GRAMMAR TYPE SCHOOLS IN MALTA

SUZANNE GATT

**Abstract** – *This paper studies the school differences in performance in Physics in the last two years of compulsory secondary education in Malta. Five grammar type schools are included in the study. Students' performance in their fourth year annual Physics examination and the Secondary Education Certificate (SEC) School leaving examination one year later are considered. The longitudinal study shows that although there is a correlation between the fourth form annual examination and the papers for SEC Physics up to a value of 0.68, a shift in performance from one year to another was observed in certain schools, especially in one girls' school which registered a drastic decrease in performance from one year to the next. It is argued that these school differences, which may also reflect gender differences since schools are single sex, reflect the still prevailing attitude in Malta for the male to be the family breadwinner. This seems to be the case mainly in families from a lower socio-economic level, as in the catchment area of the girls' school in this study. The implications of differences in performance within and across schools is then discussed.*

## Introduction

*M*alta is a country with no natural resources. Besides the sun and sea, its only resources are its own inhabitants. As a country it therefore strives to have the best possible human resources such that it can sustain its economic development. Consequently, education is highly valued with a large proportion of the country's budget invested in it. In recognition of the need for the provision of a highly trained and efficient workforce, science education plays an important role since it ensures the supply of a number of scientists in the form of researchers, engineers etc to the local industry. It is therefore essential that good science education is provided in the country.

During the last few years, Malta has seen the number of students sitting for their school leaving examination in Physics increase steadily from about 1000 in 1970 (Bonnici, 1994) to well over 3000 in 1999. The major increase took place in 1979 when it was announced that physics would be compulsory for entry into the academic stream of post-secondary education as from 1982. Although as from 1997 any science rather than physics is compulsory for entry into post-secondary

education, the number of students sitting for the Secondary Education Certificate (SEC) physics has remained high.

The percentage of students obtaining their SEC Physics, however still makes up a small percentage of the total cohort in any year. In 1996, out of 2494 candidates, 1261 boys and 1233 girls sat for the SEC Physics (Abdilla *et al*., 1998). The percentage rate was 55%. When one takes the total student cohort in that year, these amount to 5200. The percentage of students who obtained their SEC Physics then amounts to about 25% of the total student population in that year.

Examiners' reports (MATSEC, 1997) point out that the lack of understanding of concepts was reflected in the students' responses. Many responses, rather than indicating understanding, reflect students' tendency to resort to rote learning. Problems of understanding in Physics were also identified in a number of the studies carried out by a number of researchers (Camilleri, 1996; Mangion, 1997).

This research focuses on students' performance in Physics at secondary school and the subsequent performance in SEC Physics one year later by the same students. Students attending Junior Lyceum schools which are grammar type schools are considered in the study. It aims to identify differences in performance across gender and schools. As a longitudinal study, it also involves a comparison of students' performance in the last two years of their secondary school with the intention to try and identify differences that may arise in performance both between and within schools over this time interval.

## Context

Compulsory education in Malta starts at the age of 5 with primary school where children spend the following five years. At the end of primary education, most students sit for a competitive national eleven plus examination. Regardless of success in this exam, all students proceed to secondary education which lasts up to the age of 16. Students who pass the eleven plus examination attend grammar type schools, called Junior Lyceum schools. Only about half of the students sitting for this examination pass. The other half who 'do not make the grade' attend area secondary schools. All students at secondary level, regardless of which school they attend, follow more or less the same curriculum.

All students attending government schools study Physics. At the end of secondary education, students sit for the National school leaving examinations, the Secondary Education Certificate (SEC) run by the Matriculation Examination Board (MATSEC) of the University of Malta. Grades given range from 1-7, 1 being the highest and 7 the lowest.

Physics SEC consists of three components. Two components consist of a written paper while the third part involves course work. Paper 1 consists of ten compulsory short questions and is done by all candidates. Two versions (A and B) exist for Paper 2. Paper 2A is the difficult version and allows grades from 1-4 during the years for which results are considered. Paper 2B is the easier version and allows grades from 4-7 to be obtained. Both versions consist of five compulsory long questions. The coursework component amounts to 15 % of the total grade and involves presenting the write up of fifteen Physics experiments carried out at school.

Education in Malta is provided by a number of different sources. These involve government, Church and private or as know Independent schools. About 30% of students attend Church schools. Private schools cater for a much smaller percentage of the student cohort. A particular feature of Church schools relevant to this research is entry, done through a competitive eleven plus common entrance examination in the case of boys. This is due to a number of boys' Church schools catering only for secondary education. The situation is different in the case of girls where most schools cater for both primary and secondary and entrance criteria do not involve achievement.

All government and Church secondary schools are single-sex. Only the Independent schools are co-educational.

## Theoretical background

Students' examination performance has been an area of research interest to Maltese educators in a number of subjects at both primary and secondary level secondary. A number of studies were conducted on students' performance in Mathematics (Craus, 1993; Fenech and Pisani, 1998; Grima *et al*.,1995; Schembri, 1997; Vella, 1998); Enlgish (Baldacchino, 1998; Micallef and Galea, 1991); Maltese (Borg, 1983) and also Physics (Abdilla *et al*., 1998; Apps, 1989; Gatt 2002; Ventura and Murphy 1997,1998).

Studies in achievement in Physics have been carried out both for students during their secondary education and for performance at SEC level. Apps (1989) studied the performance of fourth form Junior Lyceum students in their Physics annual examination. She reports that girls in such schools performed significantly better than boys in their fourth form in the same type of school. Borg (1994) reports a similar trend, extending the research both across years, taking levels from forms 1 to four and across subjects, including English, Mathematics and Maltese as subjects. Borg (1994) argues that the girls' better performance can be explained in terms of a creaming off effect which occurs due to the common entrance examination for Church schools which takes place for boys. The placements in

Church schools occur due to order of merit, and so it is the best achievers who are offered a place at such schools. This would consequently result in most of the best students being taken up by Church schools.

Ventura and Murphy (1997) studied students performance at SEC level. They consider SEC performance over a number of years in a number of subjects. They report that statistical significance was obtained in 1994, 1995 and 1996 in favour of girls for Maltese, the national language. The same trend was obtained in 1995 and 1996 for English. An opposite trend in favour of boys was obtained for mathematics as would be expected. Physics proved to be the most interesting subject with no statistical significance obtained except in one particular year, 1994 where girls' performance was found to be better than that of boys.

Gatt (2002) considered SEC Physics results for the years 1997 and 1998 and similarly reports no statistical difference in 1997 but in favour of girls in 1998. In a further analysis of the different components of the examination Gatt (2002) shows that although no or little difference is found when one considers the overall grade, there actually exist gender differences in the different components of the examination. So boys were found to perform significantly better than girls in the written paper 1 of the examination in 1997. Girls, on the other hand, were found to perform better in the coursework component. The latter difference was found to have an effect size of 0.3 which would explain why although coursework carries only 15% of the overall grade, this difference was enough to make girls either perform as good or better than boys in Physics.

Ventura and Murphy (1998) considered school differences showing that both a gender and school type difference is present but no interaction between them. They point out that private schools (by private they refer to Church schools) outperform government schools for both boys and girls across many subjects. In fact the list of subjects includes Maltese, English, Mathematics, Physics, Italian and Religious Knowledge. However, in this analysis, Ventura and Murphy (1998) have combined together results of Junior Lyceum and Area Secondary schools. It is therefore not possible to apply such a difference to Junior Lyceum students since Area secondary students tend to be weaker and thus have lower academic achievement.

Gatt (2002), has considered performance in SEC Physics 1997 and 1998 and compared performance between Junior Lyceum students and Church school students. She has also looked at differences in performance in the different components of the examination. The study shows that Church school students outperform Junior Lyceum students with a p-value <0.001 and an effect size of 0.49 in Paper 1, and 0.32 in Paper 2A. An opposite trend, however, is obtained in the coursework component, the effect size being 0.37. The latter difference is easily explained since government schools are better equipped with laboratories and students perform much more than the minimum of fifteen experiments

required. This enables students to present their best fifteen experiments, thus allowing students to obtain a high proportion of the marks allotted to coursework. Church schools, on the other hand, have fewer facilities and perform fewer experiments. Overall difference, however, still remains in favour of students attending Church schools, the effect size being 0.32 for the overall grade obtained.

## Aim of research

As already stated in the introduction, this study looks at performance in Physics by Junior Lyceum students. It is different from the studies reviewed in that it is a longitudinal study and traces the performance of the same students over the last two years of their secondary education. So it will be able both the compare the students' performance across gender to test whether results are consistent with findings obtained so far. It will also be possible to compare school performance from one year to another to see if shifts in level of achievement between one school and another occur.

The research questions can therefore be listed to be:

- Is there a difference in performance between boys and girls attending Junior Lyceum in the fourth form annual examination?
- Does a school difference in performance exist in performance of fourth form Physics annual examination?
- Do gender and school differences occur one year later in SEC Physics?
- If differences are obtained, do they reflect the same trends that were identified for the annual examination one year earlier?
- Is there a correlation between examination performance at Form four and performance at SEC one year later, and if so, what is the correlation with the different components of the examination?

## Methodology

This section will include details of the measuring instruments used, how the data was obtained and the way the data was analysed.

### Instruments used

The measuring instruments were the students' annual examination results at the end of form IV and SEC Physics results of the same students one year later.

Students in the same form in all Junior Lyceum students sit for a common end of year examination for each subject. The examination papers are prepared at the test construction unit within the central examination department. The paper is designed such that students have to answer all questions. All areas covered during the scholastic year are examined. The paper also has the same format as that used in the SEC. Teachers at the respective schools correct the students' papers. Moderation of papers is done regularly. Results are expressed as a value out of 100. Results for the examination of form IV students in June 1996 were obtained.

A team of examiners sets SEC Physics papers. All questions in both papers are compulsory ensuring that assessment covers all areas of the syllabus. SEC results are compiled from the students' performance in the different components of the examination. For the purpose of this study, the separate performance in the different components was obtained together with the overall grade. SEC results for the 1997 SEC examination were considered.

## Data collection

The annual examination results were collected from the respective schools' records in September 1996. All schools were helpful, providing photocopies of the results to ease work. The 1997 SEC Physics results were provided on an Excel program and students' names supplied such that it would be possible to compare performance by the same students in their annual examination.

### Sample

The sample in the study included all Form IV students in Five Junior Lyceum schools in Malta. All the students in the particular schools were included rather than a representative sample since the schools streamed students according to ability. It was, therefore, difficult to obtain a representative sample of the Junior Lyceum students. Taking the whole school population solved the sampling problem.

A total of five Junior Lyceum schools, 3 boys' and 2 girls' schools were chosen out of a total of eighth school in Malta. Since schools have different catchment areas, care was taken to choose the schools in such a way as to ensure uniform demographic distribution. Three boys' schools were chosen since boys' schools tend to be smaller in size than those for girls. An additional school will therefore ensure a better balance between sexes. A total of 870 students were included in the sample, 396 boys and 474 girls, covering all the classes in the chosen schools.

**Results**

Results were available for 837 of the student cohort. This was due to a number of students being absent on the day of the examination. The distribution of marks for the form IV annual examination in Physics shows a range from a minimum of 3 to a maximum of 99. The mean was 51.24 with a standard deviation of 21.07. A measure of Skewness was 0.063 showing that a nearly normal distribution obtained. The large standard deviation could have been obtained due to a degree of discriminating power in the examination papers set.

*FIGURE 1: Distribution of Marks for From IV Junior Lyceum students Physics annual examination in 1996.*
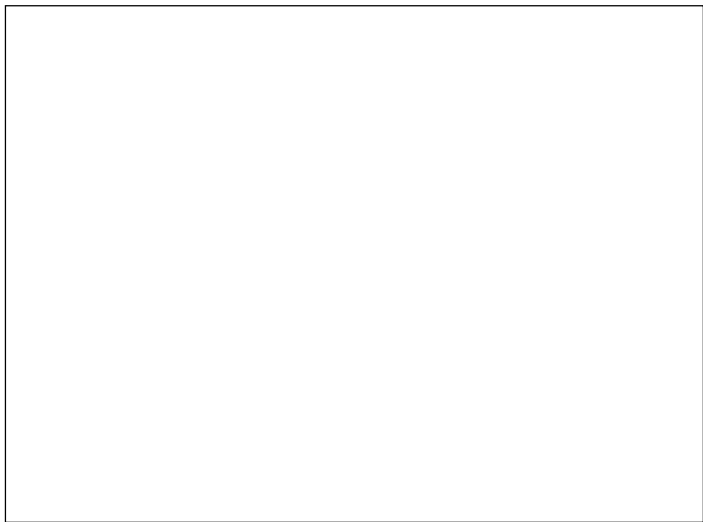


*Gender and examination performance in form IV Physics Annual Examination*

A t-test carried out across gender was found to be statistically significant with a t-value of 10.33 and p-value of 0.001. Table 2 below shows that the effect size is significant at 0.47 with girls performing better than boys by a percentage difference of nearly 10%. These results are similar to those found by Borg (1994, 1996) and Apps(1989) who both reported significantly better examination performance by form IV girls over boys in the same type of schools.

*TABLE 1: Examination results for Form IV Annual examination across Gender*

| Subject | Mean | | Mean difference | S.D. | Effect size |
|---------|------|-------|-----------------|------|-------------|
|         | Boys | Girls |                 |      |             |
| Physics | 45.83 | 55.68 | 9.85 | 21.07 | 0.47 |

One cannot, however, conclude that Maltese girls are generally better academic achievers than boys. As already highlighted, the situation in Malta is that an additional 11+ examination for entry into boys' Church schools exists. The number of vacancies at secondary level for October 2001 was only for boys and amounted to 473 students in 9 schools (The Sunday Times, 2001). Since entrance is through a common exam, selection via performance is used, leading to creaming off of the best elements into these schools, leaving Junior Lyceum schools with less able students (Borg, 1994). This is not the case for girls where most Church schools start off from nursery and lead up to secondary. It can also be noted that the number of boys attending Church schools is greater, with 2236 for boys, compared with 617 in the case of girls (Government of Malta, 1995).

The argument in favour of creaming off is further substantiated by the analysis carried out Ventura and Murphy (1997) who reported that in the SEC examinations the only statistical significance was obtained in 1994 and it was in favour of girls. Abdilla et al. (1998) also show that both boys and girls in Church schools outperform students from Junior Lyceums. However, the difference is somewhat greater in the case of boys.

*TABLE 2: SEC Physics Paper 1 Performance May 1996 Session*

| School type | Girls | | Boys | | P-value of t-test |
|-------------|-------|------|------|------|-------------------|
|             | No.   | Mean | No.  | Mean |                   |
| Private (church)Schools | 383 | 55.58 | 649 | 53.68 | <0.001 |
| Junior Lyceum Schools | 628 | 47.31 | 340 | 44.13 | <0.001 |

(Abdilla *et al*. 1998)

Ventura and Murphy (1998) also show that "private schools outperform government schools for both boys and girls. This indicates that there appears to be some creaming off for both boys and girls but does not indicate the extent to which this takes place. If one considers the number of boys and girls in Church

schools the number of girls is much smaller, indicating that less girls are absorbed by the private schools.

*Schools differences for form IV Physics Annual Examination*

A one-way ANOVA carried out across schools was found to be statistically significant with an F-value of 6.71 and a p-value <0.001. Schools 1-3 were boys' schools whereas schools 4 and 5 were girls' schools. The girls' schools have outperformed the boys schools throughout, reflecting the gender difference which was identified. However, differences across schools also emerge.

*FIGURE 2: Distribution of marks for Physics Form IV Annual Examination across schools*

School 4 was found to be the best performer in physics with school 5 following. School 1 is the weakest school from the boys' schools while schools 2 and 3 performed more or less at the same level. Whereas gender differences could be explained in terms of creaming off in terms of boys, school differences are more difficult to explain and no straightforward reason can as yet be put forward.

*SEC physics results*

Grades obtained by students have been awarded points from 0-7, with a zero for U, and then increasing from 1 up to maximum points of 7 as performance improves from grade 7 to the top grade 1. This method is similar to that adopted by Ventura and Murphy (1998). The actual marks obtained in Paper 1 of the exam are also considered. These marks should give a more accurate picture of differences in performance. Since two versions of SEC – Option A for the better

students with possible grades 1-4 and U (these students could have obtained a grade 5-7 had they chosen option B), and Option B for weaker students with range 4-7 and U (these candidates cannot obtain a grade 1-3, however well they do in their exam), differences in grades obtained may be due to choice of paper type opted for in Physics rather than in performance. Since Paper 1 is common for all students, this possible interference is eliminated.

*Gender differences*

A MANOVA carried out for Paper 1, Practical work and Grades as the dependent variable across gender as the independent variable gave a main effect. Papers 2A and 2B were not included due to the number of empty cells in each case.

*TABLE 3: MANOVA results for Gender as the independent variable*

| Multivariate Tests | Test | Value | df | Sig. |
|---|---|---|---|---|
| Gender Univariate | Hotelling's Trace | 3.726 | 3 | 0.037 |
| Gender | Paper 1 | 0.148 | 1 | 0.700 |
| | Practical | 5.318 | 1 | 0.021 |
| | Grades | 1.326 | 1 | 0.250 |

The only gender difference present is that of girls over boys in practical work. Separate t-tests carried out for papers 2A and 2B across gender also do not give any statistical difference. A look at the means for every part shows a better performance by girls even though not statistically significant. The difference obtained for practical work is large enough amounting to an effect size of 0.5, which is significant, and to result in an overall effect. On the contrary, form 4 annual exams done by the same students one year before had shown a significantly higher performance by girls over boys. It appears that boys have caught up with girls in their last year of schooling. However, it may be that one of the schools fared much better or worse, affecting the overall result. This issue will be discussed further on when the separate schools are considered.

*School differences*

A MANOVA carried out with paper 1, practical and grades as the dependent variables across school as the independent variables gave a main effect.

*TABLE 4: MANOVA results across Schools as independent variable*

| Multivariate Tests | Test | Value | Df | Sig. |
|---|---|---|---|---|
| Schools | Hotelling's Trace | 34.622 | 15 | <0.001 |
| Univariate | | | | |
| Schools | Paper 1 | 6.208 | 5 | 0.018 |
| | Practical | 2.763 | 5 | <0.001 |
| | Grades | 4.601 | 3 | <0.001 |

School differences are yet again present and can be identified both at coursework level and in the written exam. Separate ANOVAs carried out for Papers 2A and 2B across schools gave a main effect with F-values of 3.8 and p-value of 0.005 for Paper 2A but is not significant with a p-value of 0.082 for Paper 2B.

*FIGURE 3: Distribution of marks and grades for SEC Physics of J.L. students*
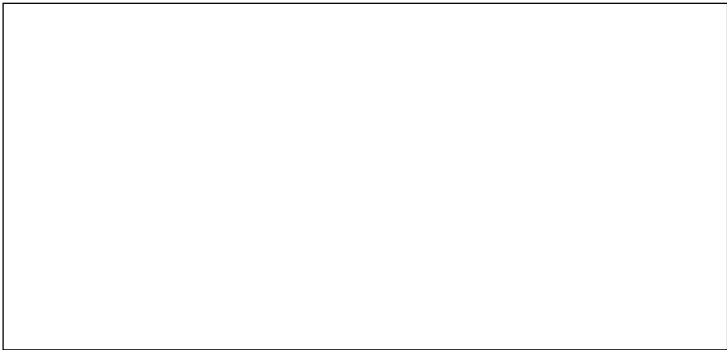


The plotted means show particular patterns. School 5 appears to have done poorly overall. This is unlike results obtained for form 4 annual exams where the performance of school 5 tended to be higher than that of boys. This poor performance is probably why no gender difference has been obtained. It appears that rather than boys catching up, it is school 5 that has done poorly. This phenomenon is difficult to explain. One possibility may be the students' catchment area. School 5 takes students from areas with a tendency for more working class backgrounds. Parents, therefore, in the case of girls, may not place as much

emphasis on education as for boys or as parents from middle class backgrounds. In view of this, either fewer invest in extra tuition or take less initiative to motivate their daughters in doing that extra effort when facing school leaving exams. In fact, in an informal interview with this school's head, she commented that on taking responsibility of the school, she had noticed that most of the girls' education ended with secondary education.

Another reason may be students' poor preparation for the examination. Students need to familiarize themselves with the type of questions set in the examination papers. Practice in tackling such questions is essential in helping students perform well. If, on the other hand, there is no such training, students will feel unprepared and so will be at a disadvantage, possibly affecting their overall grade.

*FIGURE 4: Means for grades and Practical work across schools*
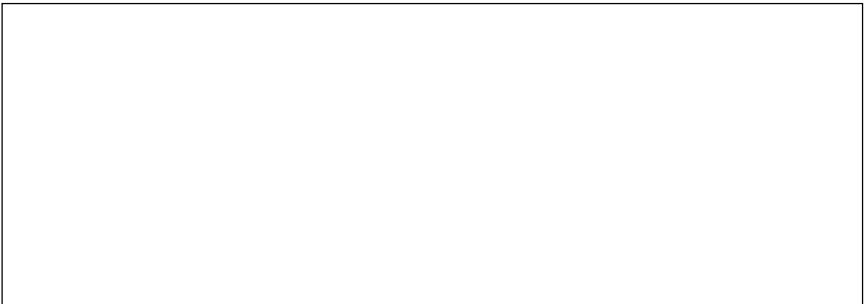


*Correlation between form IV Physics Annual Examination and SEC physics*

Correlations were worked out between the annual examination results for Form IV and the various components of the SEC Physics examination.

*TABLE 5: Correlations of form 4 annual exam with components of the Physics SEC 1997*

| Component | Form 4 Annual Physics Exam |
|---|---|
| Paper 1 | 0.678** |
| Paper 2A | 0.566** |
| Paper 2B | 0.617** |
| Practical | 0.388** |
| Grades | 0.551** |

** Statistical significance < 0.01

The fourth form annual physics exam is quite a good predictor of SEC performance. Correlations with the written papers completed under examination conditions are quite high at about 0.6. Correlation is, however, less in the case of practical work. This is understandable since practical work is done under different conditions to those of an exam. The distribution of marks tends to be less and so there is limited discrimination between students of different ability.

Although it may be considered as obvious that a good student performing well in Physics, will predictably also do well the following year, a correlation of about 0.6 also shows that effort on behalf of the students and teachers can help to improve performance over a one-year interval.

## Discussion

The study shows the presence of a degree of creaming off occurring for boys attending government Junior Lyceum secondary schools in comparison to those attending Church schools. This difference in performance can be easily explained in the case of the boys' schools. Since entry into the main boys' Church schools is through a highly competitive 11+ entrance examination in which only the best performers are successful, it is an effective way of attracting the best academic achievers.

Another possible reason may be the effect of the different pedagogies adopted by teachers in Church and Junior Lyceum schools together with the teachers' expectations. Mifsud (1994) describing a typical Church school, points out the high self esteem which such a school gives to its students. This sense of superiority promoted in students may result in better performance due to a self-fulfilling prophecy. Darmanin's (1991) study, in comparing Church and government schools, notes different pedagogies adopted in the different schools and which in turn also reflect teachers' expectations of the students' performance. Darmanin (1991a) also reports that both more boys and girls attending Church schools aspire to top managerial and professional occupations associated with service class A and Intermediate class B and C occupations than do their counterparts in government schools. She argues that even within a largely feminized sector, Church school girls are more likely to occupy higher positions than their peers in state schools.

It may have also been the case that more parents of a particular social class were keen to send their children to Church schools. In fact, Darmanin (1991) found that more class A, or professional parents sent their children to Church schools than class B or working class parents. Gewirtz, Ball and Bowe (1992) describe how in the United Kingdom those parents who work inside the system, like teachers and education administrators and which are all of a certain social

class, are particularly knowledgeable about the opportunities available for their children. They, therefore, are at an advantage and have a greater possibility of being successful in obtaining entry into the schools they choose than working class parents who often are not even aware of the possible options available. Gewirtz *et al*. (1992) also note that parents from a higher social class are even ready to send their children to schools distant from their home if they believe that their children would benefit from a better education. Working class parents, on the other hand, do not know how to exploit the market. Even when such parents were capable of achieving this, material resources or the level of the right sort of cultural capital may hinder achieving success in entry.

Such explanations give rise to the issue of social class and school choice, eventually leading to the probability of academic success. As Gewirtz *et al*. (1992) point out, 'rather than being part of a shift towards a 'classless society', choice as a mechanism of school allocation seems likely to re-emphasise and revitalize the divisions of social class in education' *(p.27)*. Sultana (1991) also makes a similar point when discussing the relationship between social class and educational achievement in Malta. He argues that this division is evident from the education structures which exist in the local educational system. He lists the main criteria for school choice in favour for Church schools to be the parents' impression that such schools provide a higher standard of education, that they give students a better religious formation, and as a means of preventing their children from mixing with students from other social classes. He overwhelmingly concludes that 'in Malta as elsewhere, 'social class' – even when this is reduced to the nominal form of 'parental occupation'– affects one's educational achievement in our formal school system' (p.248).

Another main finding of this study is the change in boys' performance at SEC level compared to their performance in their fourth form annual exam during the previous year. The apparent difference in ability between boys and girls which emerged in the fourth form, disappeared in the SEC physics exam for the same students one year later. The better performance by girls noted in form four conforms to results obtained in other studies (Apps, 1989; Borg, 1994) which also report a better performance by Junior Lyceum girls. The question now focuses as to what happens to performance during the last year of secondary education. It was noted that one girls' school in the study did particularly badly in the SEC physics exam and that it could be the case that the girls' performance was dragged down rather than the boys making a substantial improvement.

In trying to find out the cause or causes for this change in performance, two possible explanations can be put forward. One reason may be that the teachers in this particular school did not prepare the students well for the exam in that students could, for example, have faced the examination with little exposure to the style and

format of the questions set. This lack of preparation could have put the students at a disadvantage, resulting in the poor performance obtained. On the other hand, one may consider the girls' social background as another possible cause.

It is essential for students to know the format, structure and standard of the examination paper s/he is going to face during the exam. Those students who have worked out examples of previous papers will be at an advantage over those students who have not encountered similar question types before. Teachers in the poor performing school may therefore have missed out on this aspect of preparation for the exam. Likewise, teachers in boys' schools could have placed greater emphasis on providing students with examination skills, with the end result of bridging the gap between boys and girls. In addition, teachers also come to the classroom with prior experiences, assumptions and values with which they are constructing understandings about what they see as acceptable 'feminine or masculine balances' for themselves and for their students (Hildebrand, 1996) These teachers' gendered assumptions can be displayed in many ways and affect students' performance in the long run.

Another possible cause can be traced to the students' social background and the families' different expectations with respect to boys and girls. The girls' school doing badly in SEC physics has a catchment area tending to have many working class families. This is unlike the other girls' school maintaining the high achievement of the previous year. This particular school's catchment area includes mainly middle-class families, one town in particular identified by Boswell (1994) as consisting mainly of managerial and professional people. It may be that working class parents do not place as much importance to their daughters' education as they would do for that of a boy, usually still considered as the main breadwinner. Parents, therefore, would not provide as much encouragement and support for girls as they would to boys, and so the girls' performance falls. An interview with the current Head of school sheds some light on the situation. She stated that the year of the study was the first year that she took responsibility of the school and in fact she had noticed that although the cohort of students was usually quite good, few girls actually continued to further their studies with a very small percentage eventually going to University. She explained this in terms of being mainly influenced by the parents' social background and their expectations, an aspect she has been trying to fight during her years at the school. Although this is only one person's personal opinion, it sheds light on the possible factors in play. However, a study by Darmanin (1991), although not at this particular school, notes that girls have much lower job expectations than boys. Obviously, one would need to carry out a tracer study of the students at this particular school and to probe the aspirations and choices made, in order to get a better understanding of the situation, and to be in a position to draw conclusions.

The study highlights the issue of gender and the type of assessment procedure employed. Although at face value there does not appear to be any gender differences in overall performance in SEC physics, girls were significantly better performers in coursework, in physics consisting of write ups of experimental work carried out. The same effect was also registered in the United Kingdom where it was noted that girls' achievement in science and mathematics increased to match that of boys when coursework formed a substantial element of the G.C.S.E assessment (Harding, 1996). In explaining girls' underperformance in written exams, Harding (1996) argues that girls lack the necessary affective readiness. A typical explanation for girls' better performance in coursework is that girls tend to be more diligent and do their work meticulously whereas boys, on the other hand, tend to be careless which results in poorer marks. White (1996), however, argues that these stereotypic assumptions are not supported by evidence. In fact she reports that in the case of G.C.S.E English, coursework made a slightly larger contribution to the final subject mark for boys than for girls. It may, therefore, be that girls' schools are more equipped to carry out laboratory work (Xuereb, 1996) than boys' schools or that teachers in girls' schools are concerned about this aspect of the course which is then reflected in the better performance obtained.

## Conclusion

The present study looks at a very small part of students' achievement. It, however, highlights the effect that individual schools tend to have on students' performance and how this effect is not consistent across all the levels for which schools cater. Further research into individual schools' success still needs to be carried out. The research, however, shows how it is not always the case that students who do well in their fourth year, will necessarily perform just as well in their school leaving examination. The final year of compulsory education proves to be an important phase of secondary education since variations in examination performance, whether improving or regressing, tend to be significant in some schools. Schools, therefore, need to treat the final year as crucial due t its effect on determining the school leaving qualifications with which students leave compulsory education.

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# LEBANESE STUDENTS' VIEWS OF THE NATURE OF SCIENCE

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SAOUMA BOUJAOUDE

**Abstract** – *This study aimed to elucidate Lebanese middle school students' definitions of science and perceptions of its purpose and usage. Participants were 80 grade 7 and grade 8 students randomly selected from four schools in Beirut, Lebanon. Students filled an open-ended questionnaire and participated in follow-up semi-structured interviews that aimed to generate in-depth profiles of their views of the target aspects of nature of science (NOS). Participants' science teachers and school administrators were also interviewed regarding their views of the same aspects. An iterative process consistent with analytic induction was used to analyze the data and generate themes and categories that were representative of participants' views. Additionally, statistical analyses were conducted to assess whether participants' views were related to background and academic variables. Results indicated that the greater majority of participants held rather restricted views of science: they defined science as an academic subject that 'furnishes information about the world,' perceived its purpose as preparation for higher studies and careers, and mostly saw themselves and others using science in academic—rather than everyday life, settings. Student views were related to their socioeconomic status and type of school (public versus private). Participant science teachers and school administrators held equally restricted views of science. The views held by participants and their teachers are at odds with, and might hinder the attainment of, currently advocated goals for science education, which mainly aim to help students internalize more informed views of NOS as a process and a way of generating valid knowledge about the natural world that is relevant to students' everyday personal and social, as well as academic, lives.*

## Introduction

*D*uring the past two decades, the international science education community has consistently called for changing the focus of pre-college science teaching (e.g., American Association for the Advancement of Science [AAAS], 1989; Millar and Osborne, 1998; National Research Council [NRC], 1996; National Science Teachers Association [NSTA], 1982, 1993). Traditionally, this focus has been on academic scientific education, which entailed addressing the needs of a

small portion of students interested in pursuing careers as scientists or engineers. Such a narrow focus, which is reminiscent of the reform efforts of the 1960s in the United States, should be replaced with an emphasis on scientific literacy: Science curricula should cater for the needs of *all* students who, as future citizens, are capable of functioning in an increasingly scientific and technological world (Chiappetta, Koballa and Collette, 1998). This calling has been recently echoed in the new Lebanese science curriculum (National Center for Educational Research and Development [NCERD], 1997).

An emphasis on scientific literacy entails a shift from teaching the structure of science (i.e., science content and process skills) to addressing the structure, function, and nature of the scientific endeavor. Pre-college science education should abandon practices that present science as a mere disciplinary school subject that is devoid of personal meaning and divorced from students' everyday lives. Rather, science education should help students realize and experience science as a way of thinking, a means of understanding, and a tool for action that could be fruitfully applied to deal with everyday science-related personal and social issues (AAAS, 1989; NRC, 1996). For instance, science teaching should go beyond helping students solve algorithmic end-of-chapter textbook problems to tackling relevant and contextual everyday problems (NRC, 1996; Anderson, 1987; NSTA, 1993; Yager, 1989, 1991). Indeed, the fact that current science curricula rarely incorporate students' everyday experiences or provide them opportunities to apply their science understandings in relevant situations stand in sharp contrast with research findings, which indicate that emphasizing everyday applications improves students' knowledge, skills, and attitudes (NRC, 2003; Ramsden, 1994), and offers them important opportunities for cognitive growth (Saxe, 1990).

A learner's science worldview provides a framework that is used to interpret and make sense of science learning experiences (Cobern, 1996; Edmondson, 1989; Songer and Linn, 1991). Such worldview is, at least, partially related to students' conceptions of nature of science (NOS) in general, and their perceptions of the purpose of science and its usage in particular. Designing curricula and implementing instructional practices that are successful in helping students internalize the aforementioned view of science as a meaningful and functional endeavor (e.g., AAAS, 1989; NCERD, 1997) requires an understanding of how they define science and perceive its purpose, and how they think science relates to everyday life. A number of research studies investigated students' definitions of science in the United States and Canada (e.g., Charron, 1991; Griffiths and Barry, 1993; Ledbetter, 1993; Reif and Larkin, 1991; Ryan and Aikenhead, 1992; Song and Black, 1991; Songer and Linn, 1991; Urevbu, 1991). However, there is limited research on students' perceptions of the purpose(s) of science and its use in everyday life. Moreover, both lines of research are non-existent in the Lebanese context.

The new Lebanese science curriculum is still in its initial implementation and revision phases. These revisions could benefit greatly from an empirical account of Lebanese students' views of science and its use in everyday life. Such an account could also inform science teachers and help them modify their teaching practices with the aim of providing students with more meaningful and relevant science learning experiences. However, it has long been realized that teachers are the primary intermediaries of the science curriculum (Brown and Clarke, 1960) and that the successful implementation of curricular or instructional changes requires the support of school administrators (NRC, 1996). As such, it is crucial that any exploration of students' perceptions of the target aspects of NOS be coupled with exploring the views of science teachers and administrators of the same aspects.

Thus, the purpose of the present study was to elucidate Lebanese middle school students' definitions of science and perceptions of its purpose and use in everyday situations, and the relationship between these students' views and selected background and academic variables. A secondary purpose of the study was to elucidate the views of science teachers and administrators of the same aspects of science. The specific questions that guided the present investigation were:

(1)   What are participants' definitions of science and perceptions of its purpose(s)?
(2)   Where and how do participants see themselves and others using science, particularly in relation to everyday life situations?
(3)   Are participant students' perceptions related to background variables, including school type (private *versus* public), grade level, sex, achievement, and parent's (or primary provider's) occupation?

## Background

The past two decades have seen a shift in the goals of science education in response to social pressures to prepare citizens who are decision makers. The emphasis of science curricula has shifted from the structure to the structure and the function of science (AAAS, 1989; Anderson, 1987); from science that prepares scientists and engineers to science that helps people deal with practical or day-to-day problems (Ebenezer and Zoller, 1993; NRC, 1996). This change in emphasis is meant to make science more relevant to students' lives.

During the mid-1970s science curricula emphasized the conceptual structure of scientific disciplines and associated processes of inquiry. This was followed in

the late seventies and early eighties by the 'back to basics' movement, which resulted in teaching very specific knowledge objectives to the neglect of more general process-oriented ones. However, starting with the early eighties, there was a shift toward science-technology society (STS) objectives and in some cases to science-technology-environment-society (STES) objectives (Chiappetta et al., 1998; Sammel and Zandvliet, 2002; Zoller et al., 1990). Science in the STS and STES frameworks is presented in the context of science-technology related issues and scientific inquiry is presented as inquiry into personal, environmental, and societal problems for the purpose of making informed decisions (Trowbridge, Bybee and Powell, 1999). Both teachers and leaders in science education supported the STS movement and its functional goals (Mcintosh and Zeidler, 1988; Waks and Barchi, 1992; Ramsey, 1993).

Nonetheless, while the STS and STES goals have been accepted theoretically in the science education community, in practice, science teachers continued to emphasize the preparation of students for higher grades (Beisenherz and Yager, 1991; Trowbridge *et al.*, 1999), neglect the social dimensions of science, and describe science in terms of exploring the unknown and discovering new things (Rubba and Harkness, 1993). Teachers did not attempt to link science to students' everyday life. These teaching practices transformed science into a 'set of inert ideas that are not generative, not interactive with the explanations children have constructed themselves for natural phenomena' (Hawkins and Pea, 1987, pp. 298-299). More recently, the goals of the STS movement and the associated functional perceptions of science were subsumed under the more global umbrella of scientific literacy (e.g., AAAS, 1989, 2001; NRC, 1996).

Students and science teachers' definitions of science were found to be remarkably similar (Ledbetter, 1993). Research on students' views in the United States has shown that they ascribe to a restricted view of science. Students perceive science as a school subject with no relevance to real life (Charron, 1991; Reif and Larkin, 1991; Song and Black, 1991; Urevbu, 1991). Ryan and Aikenhead (1992) and Griffiths and Barry (1993) asserted that the majority of their participants perceived science as a body of knowledge or the study of science fields such biology and physics. Ledbetter (1993) has shown that science as discovery, school centered activities, and natural phenomena and their actions were the top three definitions of science presented by grade 7-12 students.

Charron (1991) found that elementary students associated science with active doing while high school students associated it with passive learning. Moreover, she found that most students and their parents thought that science had almost no bearing on their everyday lives. Songer and Linn (1991) reported that middle school students held three types of views about science: static, dynamic, and mixed. Students who ascribed to the static views affirmed that science is a

collection of facts that are best learned through memorization. Students who characterized science as dynamic ascertained that science is tentative and that understanding science is the best approach to learning it. Finally, students with a mixed view of science held elements of both static and dynamic characterizations simultaneously. In this regard, it should be noted that holding a restricted definition of science is not limited to students. Yager and Penick (1988) found that members of community organizations realized the necessity of teaching science for daily living but their priority was for academic preparation. Furthermore, research has shown that elementary science textbooks focus on academic preparation while neglecting the relevance of science to students' lives (Staver and Bay, 1987).

Several approaches have been advocated to help students internalize the relevance of science to everyday life. In addition to the aforementioned STS movement, O'Brien (1993) advocated using toys in science teaching to extend learning beyond the classroom and provide students with opportunities to see science in action. Roth (1992) and Sanders (1994) envisioned a role for technology in bridging the gap between classroom and real life situations. Sanders (1994) suggested using science activities to give middle school students a chance to see real-world applications for science, mathematics, and technology. Roth (1992) argued for providing students with opportunities to use computers in solving ill-defined problems that are similar to real life problems, which are rarely experienced in the science classroom. Finally, according to Martin and Brouwer (1991), one way to make science relevant to students' lives is by using stories, narratives, and anecdotes that 'open up the possibility of involving the imagination of students and . . . demand participation from students [because] . . . . students themselves are involved in giving meaning to the stories, and such stories resonate with the lives of individual students in personal ways' (p. 719).

## Method

*Participants*

Two private and two public schools in Beirut, Lebanon participated in the study. The schools were randomly selected from a list of private and public schools available in the Lebanese Ministry of Education. One grade 7 and one grade 8 classroom were randomly selected from each school and ten students from each of the resulting eight classrooms were chosen to participate in the study. Participant students were 80 middle school students (50% female) with an age range of 11–13 years. The selected students represented a range in terms of

socioeconomic status and achievement levels. Additionally, the selected six classroom science teachers (in the case of two participant schools, grade 7 and grade 8 were taught by the same teacher) and the four school principals were asked to participate in the study.

*Procedure and instruments*

An open-ended questionnaire in conjunction with follow-up individual interviews was used to explore participants' views of the target NOS aspects. This approach was used with the intent of avoiding the problems inherent to the use of standardized forced-choice or convergent instruments, such as the *Nature of Science Test* (Billeh and Hasan, 1975) and *Nature of Science Scale* (Kimball, 1967-68), which have been traditionally employed to assess learners' NOS views. These problems stem from the assumptions underlying the development of these instruments and their format, and cast serious doubt on whether such instruments generate valid assessments of respondents' NOS views (Abd-El-Khalick, Lederman, Bell and Schwartz, 2001). By comparison, open-ended questions allow respondents to express their own views on the target issues related to science and alleviate concerns related to imposing a particular view of the scientific enterprise on respondents. Moreover, coupled with data from individual interviews, responses to open-ended questions allow the assessment of not only respondents' positions on the target issues, but the respondents' reasons for adopting those positions as well (Aikenhead, 1988; Aikenhead, Ryan and Desautels, 1989).

An initial set of open-ended questions was piloted through individual interviews with 10 students from schools similar to those participating in the study. These questions were modified according to students' responses, comments, and feedback, and used to construct the open-ended questionnaire. The resulting questionnaire was piloted with another 10 students and further modified. Since the medium of science instruction in Lebanon is either French or English, the questionnaire was written in both languages. Care was taken to insure the consistency between the two versions of the questionnaire. This was established by translating the questions from English to French by one expert and back to English by a second expert. Then, the initial set of questions in English was compared to the final translated set to insure that translation did not change the content of the questions. This iterative process resulted in a final set of four questions that were comprehensible to participant students and that helped to elucidate their views of the target aspects of science. The questions were:

(1)  What is your definition of science? What comes to your mind when you hear the word science?

(2)   What is the purpose of science? Why do you study science?
(3)   Did you use science in the past few days? Where? How did you use science?
(4)   Did you see others using science in the past few days? Where? How did they use science?

All participant students filled out the questionnaire and sat for individual interviews approximately two weeks later. During the interviews, participants were asked the same set of questions as on the questionnaire. These questions were often followed by clarification and probing questions. The two investigators conducted the interviews in a relaxed environment and in the language in which the participants felt most comfortable. Consequently, most students used Arabic with some English or French words. The interviews lasted between 15 and 35 minutes each and were audio-taped and transcribed verbatim for subsequent analysis. These interviews allowed checking the consistency of participants' responses and probing their views in depth. Participant science teachers and school administrators were also interviewed using the same set of questions.

Information about school type (public *versus* private), and participant students' sex, grade level (grade 7 or grade 8), achievement (high, middle, or low), and father's occupation (professional, semiskilled, unskilled, or unemployed) was collected during the interviews and from school records. In this regard, it should be noted that the background variable 'mother's occupation' was not used in the present analysis because very few students reported having working mothers.

*Data analysis*

There were two phases of data analysis. The first phase was conducted using the process of analytic induction (Bogdan and Biklen, 1982; Goetz and LeCompte, 1984). This process involved scanning the questionnaire and interview responses for categories and relationships among categories, and 'developing working typologies and hypotheses upon examination of initial cases, then modifying and refining them on the basis of subsequent cases' (Goetz and LeCompte, 1984, p. 180). The investigators conducted the initial stages of data analysis of this phase independently. Following each stage they met to discuss the results and resolve any differences in the categorization. They collaborated, however, on the last stage of analysis and the final set of categories and frequency counts were a result of this process. Data analyses showed that some participants' responses contained more than one type of category. Consequently, the reported percentages do not always add up to 100% and a higher percentage suggests that a certain category appeared more often in the responses.

The second phase of data analysis explored the relationship between participant students' perceptions, and background and academic variables. This exploration was achieved by combining categories into more inclusive ones, which resulted in reducing the number of categories and allowed coding each participant under one category. This process, however, presented the problem of coding the responses of 15 students that appeared to belong to more than one category. The problem was resolved by coding the responses based on the first category appearing in the response. The assumption was that the first response was more spontaneous and thus more representative of a participant's views. Then, the data were analyzed by investigating the possible relationships between the generated categories and each of the aforementioned variables (i.e., school type, grade level, sex, achievement, and parent's occupation) using non-parametric Crosstabs and Chisquare of the statistical package SPSS for Windows, Version 10.0.

## Results

Participant students' views of the target NOS aspects were similar to a large extent to those of their teachers and school principals despite differences in the complexity of the language used to convey these views. The following sections will primarily focus on reporting the results for the student participants, where comparable categories resulted from analyzing the questionnaire and interview responses. While higher frequencies for each category emerged from the interviews, the percentages were similar for both interviews and questionnaires. The results presented in this paper are those derived from analyzing the interview transcripts since they offered a richer and more detailed data source than the questionnaires.

### Students' definitions of science

Six definitions of science emerged from students' responses. The majority of students (63.8%) noted that science was a subject that 'gave information' about humans, animals, plants, the earth, the sky, and/or the stars. The second most common definition, which accounted for 35% of student responses, suggested that science was a subject matter divided into other subjects such as physics, chemistry, and biology. Science as 'a method for doing things' and as 'a subject to teach us new things' tied for third rank: These two definitions appeared in the responses of 18% of the students. Next, 16.3% of the students proposed that science was 'a subject that enlightens and leads to truths about nature.' Finally, science as a subject studied in class appeared in the responses of 10% of the students.

*Students' perceptions of the purposes of science*

Students discerned six main purposes for science. These were: Academic preparation, preparation for future careers, achieving higher social status, helping people solve everyday problems, discovering new things, and helping people appreciate and understand nature. Table 1 presents these categories, and their definitions (in students' terms) and associated percentages. The most commonly stated purpose of science was academic preparation, followed by preparation for future careers. The third most commonly stated response was achieving higher social status. It seems that students have been socialized to think that science-related professions – referring specifically to occupations in the engineering and medical fields, were associated with high social status in Lebanon. Consequently, for these students, the purpose of science was to prepare them for these professions. Indeed, these three categories were interrelated in the thinking of many students: 55% of those students who noted that the purpose of science was to prepare them for future careers also included academic preparation and social status in their discourse regarding the purpose of science. In addition to the above categories, 17.5% of student responses indicated that they realized the importance of science in everyday life. Finally, a minority of students said that the purpose of science was to discover new things (8.3%) and to help people appreciate and understand nature (5%).

*Students' perceptions of their use of science*

To be sure, some students noted that they never used science. However, the majority of students believed that they used science in four domains. These were using science in academic settings; to solve everyday problems; in hobbies, during play or when engaging sports activities; and when performing activities related to their bodies or during sickness. Utilizing science in school settings, such as doing science homework, preparing for examinations, answering science questions in class, and working in the laboratory, was the use reported by 66% of students. Only 13% of the participant students noted that they used science to solve everyday problems, such as changing light bulbs, checking for gas leaks, fixing radios, taking care of plants, and dealing with farming-related activities. Eight percent of the students said that they used science in hobbies, during play, or during sports activities. Under this category, students mentioned playing with magnets, building small engines, playing basketball or soccer, and building model boats and airplanes. Another 8% of students said that they used science when they performed activities related to their bodies or during sickness. Examples provided under this category included eating, drinking, falling ill, or breaking a leg. Finally,

*TABLE 1: Purposes of Science as Perceived by Participant Students*

| Category | The purpose of science is to: | Percent |
|---|---|---|
| Academic Preparation | Teach us about animals, plants, the world, and life | 52.2 |
| | Prepare us for higher studies and higher classes | 11.3 |
| Future Careers | Prepare us for future careers | 46.5 |
| | Help us achieve our goals and succeed in life | 11.3 |
| Social Status | Answer questions and take part in conversations in, and out of, school settings | 21.5 |
| | Give higher social status | 8.8 |
| Solving Everyday Problems | Help people in their daily lives such as in deciding what to eat, how to take care of oneself, and how to fix things | 17.5 |
| Inventing and Discovering | Discover new things that improve their standard of living | 8.3 |
| Understanding Nature | Help people become closer to nature and to understand their surroundings | 5.0 |

19% of the students said that they did not use science regularly. When these students were asked to elaborate, they were unable to think of any use of science except an occasional mention of 'studying science.'

*Students' perceptions of the use of science by others*

There were eight categories of perceived science usage by others, the most prevalent of which were associated with academic and career related activities. Thirty-six percent of the students noted that they saw others using science in school settings, such as teachers teaching science, classmates studying science, or teachers and students performing laboratory experiments. Another 18% said

that they had seen others using science in academic related activities outside the school including seeing friends studying science, siblings performing required experiments at home, and relatives preparing to teach science lessons. About 31% of participant students believed that professionals, such as doctors, engineers, electricians, nurses, pharmacists, and mechanics, used science. Other categories elucidated by participant students included seeing science being used by individuals in the media, such as in television programs or the movies (8%), parents when reading science related books or magazines (8%), and athletes during sports competitions (4%). A mere 4% of all students said that they saw others using science in solving everyday problems. Examples of activities given under this category included fixing radios and other electrical appliances and farming. Finally, 5% of the students said that everybody used science and 18% said that they did not remember seeing or encountering others using science.

*Relationship between students' perceptions, and background and academic variables*

Frequencies resulting from the second phase of data analysis were examined using the background variables of school type, grade level, sex, achievement level, and father's occupation. The results of this analysis are presented in the following sections.

*Definition of science:* Three categories of the definition of science were used in this analysis: Science as a school subject, science as doing, and science as the 'truth.' Students' definition of science differed by school type ($c_2 = 20.9$, $p < .05$). Definitions provided by students in the two public schools were different from those of the private schools and from each other. Eighty-five percent of the students of one public school (Public-1) defined science as a school subject as compared to 65% in both private schools and 40% in the second public school (Public-2). Also, 5% of the students in Public-1 defined science as the truth as compared to 50% in Public-2 and 10% in the two private schools.

*Purpose of science:* Three categories were used in the analysis: Academic preparation for careers, solving everyday problems, and inventing and discovering. There were no statistically significant differences on any of the possible relationships in this analysis. However, several differences, while not significant, were intriguing. In particular, the lowest percentage of students who noted that the purpose of science was to solve everyday problems came from the public school (Public-1) in which the largest percentage of students defined science as a school subject. Moreover, more students in the private schools than

in the public ones said that the purpose of science was to solve everyday problems. Finally, more females than males believed that the purpose of science was to invent and discover new things.

*Students' use of science:* All aforementioned five categories were used in the analysis. These were using science: in academic settings; to solve everyday problems; in hobbies, during play, or during sports activities; and when performing activities related to the body or during sickness; and not using science. There were statistically significant differences by school type ($c_2 = 25.8$, p < .05) and father's occupation ($c_2 = 24.9$, p < .05). More students in the public than in the private schools said that they did not use science. Also, more students whose fathers were professionals said they used science in hobbies and body-related activities and more students whose fathers were unskilled or semiskilled said that they used science in academic settings. Even though not statistically significant, it is worth noting that more females than males said that they did not use science while more males than females said that they used science in hobbies.

*Students' perceptions of science usage by others:* Five of the eight categories of students' perceptions of science usage by others were included in the analysis. These were 'nobody uses science,' 'everybody uses science,' and use of science by others in academic settings, in careers, and in daily life. Students' perceptions of this aspect differed by fathers' occupation ($c_2 = 21.5$, p < .05). More students' whose parents were professional or semiskilled than unskilled said they saw science used by others in careers and more students whose parents were unskilled than professional or semiskilled said they did not see science being used by others. A few other interesting patterns, though statistically insignificant, emerged from this analysis. In particular, it was found that a higher percentage of students in public schools than in private schools said they saw science being used by others in academic settings.

### Administrators' and science teachers' perceptions

As noted earlier, participant administrators and science teachers held views that were similar to those of their students. Most of the aforementioned categories related to defining science and enumerating its uses were evident in the discourse of teachers and administrators. These latter participants held equally restricted and naïve views of science as a mere academic discipline and/or a method aimed at collating and documenting 'facts' about the natural world, discovering 'truths' about the workings of natural phenomena, and/or producing useful inventions that target the enhancement of the human condition. Moreover, even though a substantially larger percentage of science teachers and administrators than

students believed that everyone uses science, the domains of usage enumerated by the former participants were similar to those discerned by students. One noticeable difference in this regard was that, unlike the public school science teachers, the private schools teachers believed that students used science in hobbies and 'for fun' outside classroom settings. As it turned out, these teachers were referring to annual science fair competitions that were organized in both private schools. These fairs, nonetheless, were perceived as occasions to reinforce students' academic science learning. Finally, it is worth noting that almost all teachers and administrators emphasized the significance of science as an academic subject that would allow students to access high status science-related professions (e.g., physicians and engineers), which would greatly benefit those students and their communities. Indeed, both teachers and administrators alike took great pride in pointing out their successes in helping their students 'succeed in science' in the participant schools.

## Discussion and conclusions

Participant Lebanese middle school students, like their counterparts in the United States and Canada (e.g., Charron, 1991; Griffiths and Barry, 1993; Reif and Larkin, 1991; Ryan and Aikenhead, 1992; Song and Black, 1991; Urevbu, 1991), ascribed to a restricted view of science. The majority defined science as an academic subject, and perceived its purpose as preparation for higher grades, higher studies, and careers, and saw themselves and others using science mostly in academic settings. Only a small minority of students saw science as something relevant to their everyday lives outside the classroom when they noted that they used science in hobbies or that science relates to their bodily functions (e.g., during sickness). Students' perceptions were significantly related ($p > .05$) to the type of school in which they were enrolled and to their father's occupation. More public than private schools students defined science as an academic subject, said that they did not use science, or that they used science in academic settings. Additionally, more students whose fathers had professional careers than those who did not noted that they used science in hobbies and that they saw others using science in career settings.

The relationship between participant students' perceptions, and the type of school and father's occupation may be explicable to a substantial extent by a more global factor, namely, students' socioeconomic status (SES). Most Lebanese public schools serve students of low SES and most parents with professional degrees, and consequently higher SES, send their children to private schools. SES influences parental and career expectations to a large extent (Alexander and

Entwisle, 1988; O'Neill, 1978). In a country like Lebanon, where science is intimately associated in the public's mind with privileged and high-status careers (particularly careers in the engineering and medical fields), obtaining a professional science-related degree is perceived as a means to climb the social ladder. Thus, unskilled and semi-skilled parents tend to place *exclusive* and high emphasis on their children's science achievement and academic success, which is associated with high status careers and high income. This emphasis is translated into expectations, which are often explicitly verbalized and communicated to students. Nonetheless, these expectations are rarely coupled with commensurate support at home given the parents' restricted educational capital. This argument does not entail that Lebanese parents with professional careers and/or higher SES tend to place less emphasis on academic achievement or attaining high-status professions. However, given their educational, social, and/or economic capital, these latter parents value the holistic development of their children and often couple their high expectations with active engagement in their children's education. These parents, for instance, discuss school topics, including science, with their children and partner with them to design and execute science fair projects.

Students' definitions of science and perceptions of its purpose and usage, like other student perceptions, are not only influenced by out-of-school factors, such as parental expectations, social status associated with science, and career expectations. School-related factors, including curriculum, school administration, teachers and teaching, and external examinations, play an equally important role in shaping students' perceptions. Of these latter factors, we believe, only the curriculum has been substantially changed during the past five years. The old Lebanese science curriculum emphasized science as a mere academic subject. The curriculum was restricted to a list of science topics with an occasional statement regarding the use of science process skills. As noted earlier, the new Lebanese science curriculum that was put forth in 1997 (NCERD, 1997) represented a drastic departure from the old curriculum in terms of alignment with recent international trends in science education (e.g., AAAS, 1989; NRC, 1996). In addition to emphasizing the disciplinary structure of science, this curriculum now places emphasis on the function and NOS. However, it is not clear to what extent will this change in the curriculum bring about a change in students' perceptions of science. This is especially the case given that this curricular change has been accompanied by relatively minimal change in other school-related factors.

Among these school factors are high stakes examinations. These examinations, which emphasize knowledge and comprehension level instructional outcomes and algorithmic problem-solving (Kraidy and Fares,

1984), still determine much of what goes on in pre-college education in Lebanon. By the end of middle school, Lebanese students sit for national examinations that determine whether students are promoted to high school. These examinations also impact whether students can pursue the scientific stream in high school. Again, by the end of secondary education, students sit for even higher stakes national examinations, which represent their gateway for admission to colleges and universities. Success in these national official examinations is a prerequisite for achieving professional degrees and, thus, is given high priority by parents, teachers, and administrators. Consequently, school administrators and teachers strive to complete the specific requirements of the curriculum and adopt highly targeted instructional practices to prepare students to succeed in official examinations. Indeed, we have seen that teachers and administrators in the present study hold very restricted views of science as an academic discipline and stress its use for the academic preparation of their students.

The interaction between school and out-of-school factors has created a culture of 'science as an academic subject' that permeates all levels of education in Lebanon. This type of science education prepares students to pass examinations, enroll in college, and secure professional science-related careers. Thus, while there are no official examinations in grades 7 and 8, the major concern of parents, teachers, and school administrators is how to provide students at this level with the prerequisite knowledge and skills necessary to achieve high grades in science and pass examinations in preparation for the future. The major concern of students, on the other hand, is how to adapt to and negotiate these requirements. As such, the results of this study are not unexpected.

While anticipated, the instructional overemphasis on the structure of science, rather than on the structure, function, and NOS, may be problematic. In a developing country in which confronting environmental and other science-related issues is a major concern of citizens and decision makers, there is a need to prepare scientifically literate individuals besides preparing medical doctors and engineers (NCERD, 1997). An educational system that emphasizes science as an academic subject may produce citizens who 'know' much science but are unable to address science-related everyday and societal problems (Abou Assli, 1995). Consequently, there is a need to contemplate the possibility of incorporating everyday examples (e.g. hobbies) and ways of solving everyday science-related problems in the science curriculum and in teacher preparation programs to give students a broader view of science and render it relevant to their lives.

In this regards, two questions, which are relevant to the issue of changing the curriculum and changing students' views about science, need to be answered. First, is it possible to transform the prevailing culture by only changing the curriculum? Second, should the culture be changed if it meets students', parents',

and teachers' needs? A prevailing culture is hard to change especially when sociocultural expectations and students' specific agendas and views are compatible (Wildy and Wallace, 1995). Moreover, why should a prevailing culture be changed if it meets the needs of all stakeholders? Answers to these and similar questions are needed while considering the agendas of all those concerned with science education in Lebanon and other countries with similar conditions and aspirations.

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# BLUNTING THE TENSIONS BETWEEN INFORMAL AND FORMAL EDUCATION IN SCIENCE: REFORMING THE RELATIONSHIP BETWEEN THE SCHOOL AND THE SCIENCE MUSEUM IN GREECE

DEMETRIS KOLIOPOULOS

**Abstract –** *In this paper, I explore the relationship between formal and informal approaches to science education as mechanisms for dissemination of scientific knowledge. I then posit the combination of specific characteristics from the two approaches into a unified process of non-formal science education. In the second part of the paper, I describe the different types of science museum and present a taxonomy with respect to their educational mission. Finally, I describe the role of the three approaches in the educational system and I illustrate each one with specific examples from science museums.*

## From dissemination of scientific knowledge to developing scientific literacy

In recent years, there has been a more frequent use of the term '*scientific literacy*' (or 'scientific culture') both in school environments, and in the literature on public understanding of science. The term has been used in different contexts with different purposes (Bybee, 1997). Beyond the term we can trace the fundamental position that scientific knowledge constitutes a fundamental aspect of our civilization. This position, that scientific knowledge is a *cultural object*, which affects a society trying to function efficiently in a techno-scientific environment, in contrast to simply being a specialized object of teaching, is increasingly adopted by various educational systems and this effort is also beginning to reflect in the science curriculum. The many countries that participate in the OECD/PISA project adopt the following description: 'Scientific literacy is the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity' (OECD, 1999). Some of the actions supporting this position are the introduction of aspects of the history and philosophy of science in the curriculum, the relevance of curriculum content to problems and issues of everyday life and technology, the development structures of support in science teaching in parallel to the curriculum, and schools opening up to society, particularly to specific organizations aiming at scientific literacy for the wider public.
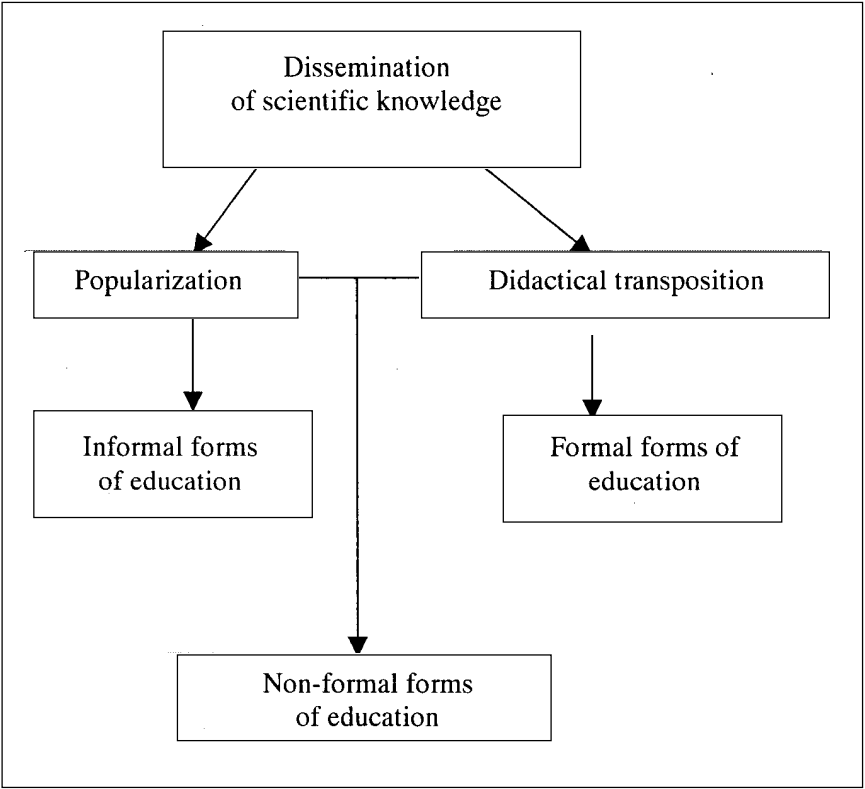
In the present study, we focus on the last action, *schools opening up to society*. Yet, since the school system is not the only factor promoting scientific literacy, it has been noted that the role of formal education, and its relationship with non-formal and informal provision, become more problematic and need further clarification (Hofstein and Rosenfeld, 1996; Jenkins, 1997). In this study, our effort is to clarify the kind and content of the relationship that can be developed amongst a formal educational system and an organization aiming to promote the scientific literacy of the wider public. A science museum can be an example an organization. Specifically the purpose of the study is to describe the nature and characteristics of this relationship, particularly in the context of the Greek environment. We also aim to elucidate ways of making this relationship productive and effective. The Greek context is typical of many countries in the Mediterranean region in that, for many years, it has been a *receiver of scientific knowledge* rather than a *producer*.

## Formal and informal forms of education in science

There are two basic mechanisms for the dissemination of scientific knowledge, (Figure 1): P*opularization* of the scientific knowledge and the mechanism of its *didactical transposition*. Popularization is associated with the dissemination of scientific knowledge to the public, whether adults or children. According to Baltas (1984), it constitutes 'an aspect of the entire social function of the scientific institution, one of the ways with which to accomplish the social acceptance of the work and role of the scientist, the ideological legalization not only of the results produced by different sciences, but also of the specific way these are applied in current societies'. Baltas (1984) also claims that, because of this 'ideological' function, popularization appears to transform scientific knowledge to a form of knowledge trying to be attractive and easily understood to the 'non-expert'. Hence, scientific popularization can be defined as the procedure which can achieve the transfer from scientific to everyday language.

The context within which the mechanism of popularization is activated is neither whole nor homogeneous. Popularization can be achieved through the so-called *informal forms of education*. The informal forms of education compose a non-organized and non-systematic field of education relating to everyday experiences and are activated outside the formal educational system. Informal education usually relies on an interaction between own initiative and the efforts of organizations disseminating scientific knowledge, participation is invariably on a voluntarily basis. Typical contexts for the to the popularization of scientific knowledge include the spontaneous engagement with technological phenomena

or problems at home or work, visits to a science museum or to a technology centre, reading scientific articles in newspapers or specialized magazines and watching TV programmes with scientific content or attending popularized lectures by scientists. Table 1 juxtaposes the various characteristics of informal and formal forms of education (Guichard and Martinand, 2000).

Informal forms of education, through the mechanism of popularization, can result in (Escot, 1999): (a) increased sensitivity on issues concerning the physical and technological environment, (b) enhanced interest in a specific topic of science, (c) the possibility of transforming a circumstantial interest in an issue to actually becoming actively engaged in it and (d) the possibilities of creating a personal scheme or even creating the conditions of self-instruction to a certain field of action. However, it still remains open to question whether the mechanism of

*TABLE 1: Comparison of the different aspects of formal and informal education*

|  | **School education** | **Informal forms of education** |
|---|---|---|
| Codification | School programme | Not a long-term scheme |
| Public | Homogeneous group in age | Different public |
| Conditions | Obligations | Freedom of choice |
| Time | School time | Free time |
| Organization / time | Smooth progressive course | Periodic activity |
| Evaluation | Validation system | Lack of validation system |
| What is at stake | Exams | Personal culture |
| Search for | Success | Pleasure and culture |

popularization and informal forms of education can achieve what popularization is primarily after: the true dissemination of scientific knowledge. According to Baltas (1984), the procedure with which the transfer from scientific to everyday language is affected, at the same time, abolishes the 'autonomy of meaning' in the scientific language. This may lead the popularized knowledge to paradoxes or to a dead end. In other words, the danger exists that scientific knowledge can appear as a new myth leading to fear, as involving ignorance or negative attitudes.

The difficulties in diffusing scientific knowledge, that are innate to the nature of the mechanism of popularization, can possibly be overcome through the mechanism of didactical transposition (Astofli and Develay, 1989). The didactical transposition constitutes all the modifications over scientific knowledge when this is to become a teaching object within formal education. Regardless of whether it might be an unconscious procedure, as it usually is in practice, or whether the object of teaching results out of systematic didactical analysis, invariably the fundamental components of didactical transposition are *decontextualizing* and *recontextualizing* the scientific knowledge. The object of teaching undergoes decontextualization since knowledge has been extracted from the scientific environment in which it has been built and the actual procedures that led to forming the knowledge in the science field are eliminated. The recontextualization of scientific knowledge relates to the demands and limitations set by the educational context, e.g. the demand for a sequence of lessons within time limits and the priorities of the teacher when conducting the teaching object in the classroom. Thus, the content of scientific concepts can be altered, since they would have to be constrained to a series of units, and their relationships reestablished in order to form a conceptual reference frame work. In this way, a

new artificial scientific frame is shaped concerning the conceptual content, an 'educational epistemology' with totally different features from the one relating to the original scientific knowledge frame. The didactical transposition is relates to the formal forms of education at all levels and for all teachers and students.

The science curriculum constitutes a basic element of structure for all forms of formal education and resumes what popularization fails to accomplish, that is to maintain the coherence and content of science theories, even if stating these theories at a more qualitative level simplifying the mathematical formulation. Of course, in certain cases where the scientific knowledge assumes purely a qualitative character, the limits of popularization and didactical transposition are difficult to discern. Such examples are commonly found in primary schools textbooks or activity books in pre-school education for many years.

The Greek curriculum in science has been dominated by a traditional perception that makes it close to impossible for the students to obtain the scientific knowledge, at least as a cultural object (Koliopoulos and Ravanis, 2000). This perception promotes a didactical transposition of scientific knowledge that is identified by dispersing units of information, extensive mathematical formalism or a 'pseudo-qualitative' approach of the concepts of science, the perception that scientific knowledge comes from experience and the underestimated use of cultural aims (Koliopoulos and Constantinou, 2002).

From the above analysis, it appears that tensions occur amongst formal and informal forms of education, due to distinct educational goals, different mediation strategies and, mostly, due to a *different epistemological approach* in the dissemination of scientific knowledge. These tensions can take a sharp character, as in the case of Greece. In the next section, we discuss how it is possible to blunt these tensions, especially on the epistemological domain.

## Non-formal forms of education in science: blunting the tensions

Profound changes have occurred over the last few years, concerning our perceptions of the nature and characteristics of scientific knowledge, and in the content and methods of education. These changes have led to a third field of dissemination of scientific knowledge. I*n this third field, the mechanisms of popularization and didactical transposition of the scientific knowledge appear to be combined*. We shall be using the term '*non-formal forms of education*' to express precisely for this field of dissemination of scientific knowledge. It is worth noting that the terms 'informal forms of education' and 'non-formal forms of education' seem to be employed interchangeably in some of the literature. We don't intend to give here an analytical definition of the term 'non-formal forms of

education' but rather an operational one. However, our approach is closer to that adopted by Evans' who defined non-formal education programmes as those activities organized outside the formal system to form part of the whole integrated concept of an education system (Mehta, 1997). So, non-formal forms of education differ from informal forms in that they involve also the formal educational system. This occurs where the limits of formal forms of education are clearly identified (e.g. the failure of the curriculum to keep up with scientific and technological changes in society, the need for increased motivation of students in science) and there is a need to expand school boundaries into society (e.g. the introduction of environmental education in the curriculum) (Orion and Fortner, 2002). The extent to which the formal system is involved varies substantially depending on the nature and characteristics of organizations offering an environment of informal education.

The non-formal forms of education in science also relate to 'extra-curriculum' activities, which may become part of the curriculum and in a way that enhances the teacher's role (Woolnough, 1994). UNESCO (1986) gives the most well-known classification of extra-curricular activities. They include student participation in science clubs, Science Olympiads, scientific exhibitions, research and project work, visits to science museums and being engaged in their projects, and, last, reading science texts of special and non-special sorts, along with watching TV and radio reports over scientific issues. It is also known that many of the above can be attained at school under the teachers' responsibility. Then, it is no wonder that many students' workshops, science clubs and are scientific exhibitions are found in schools. At the same time one can find appropriate educational projects undertaken by science museums, where the teachers' participation is crucial, since some of the most important are the preparation and follow-up activities in the classroom or the school laboratory before and after a visit. The spectacular techniques often used in science exhibitions and museums could also be practised in the classroom, presenting science as a performance able to arouse an interest, positive attitudes and advanced knowledge. Lastly, the scientific text and films can be used and commented upon during teaching, not only as additional material to be utilized by students' under their own initiative, but also as elements strongly attached to formal teaching.

Can we consider all these activities, regardless of whether they are taking place inside or outside school, as non-formal educational approaches? Not always. The *type of link* between the school environment and the uniqueness of every organization that discriminates scientific knowledge is what determines whether an activity belongs within non-formal forms of education. Therefore, an activity such as a casual or guided visit to a science museum is considered an informal form of education and can be dominated by the mechanism of popularization. Still,

the same activity can be altered into a more substantial form of education if used by the educator in a more coherent educational project in order to activate the mechanism of didactical transposition of scientific knowledge. However, this mechanism cannot be activated independently of the school since the activity needs to be guided by the goals and content of the curriculum, or of the educator, who has to participate in the conceptualization, design and practice of the activity. In this case, we refer to a non-formal form of education. In Table 2 we present examples of informal and non-formal forms of education in science for some of the activities mentioned above.

We would like to posit that non-formal forms of education present an appropriate educational environment for the development of scientific literacy within every field of science. This happens for two reasons: firstly because of the implication of the mechanism of popularization that assists dissemination of scientific knowledge and of the opportunity to freely engage in it, secondly, because of the mechanism of didactical transposition, leading to a systematic approach and evaluation of the school's position on scientific knowledge. In the following paragraphs, we describe the features of a science museum as an organization disseminating scientific knowledge and, also, explore the conditions under which a school's approach to the science museum can lead to non-formal forms of education in science. In other words, we discuss the issue of how the interaction between school and science museum can lead to appropriate environments for the unfolding of scientific literacy.

## Science museums and their educational role

The science museum represents a place where knowledge is expanded, primarily appealing to non-experts, who are interested in learning new things, facts and ideas, while of the same time being entertained. What happens within the corridors of such a museum? A slow process of integrating society, culture and science. Hervieu (1997) presents the example of Umberto Eco, who spent more than three years in the 'Musée des Arts et Métiers' in Paris, before writing his famous novel 'Foucault's pendulum'. Bibliographical and empirical research has shown that there is not a single type or unique form of science museum. We have proposed a classification that represents a wide notion of science museums, tending the traditional definition of a museum by ICOM. Our classification has been constructed entirely for educational purposes. Specifically, it aims to highlight the educational role of the science museum from the point of view of the formal educational system. So, this classification provides criteria that a teacher could use to adapt his/her teaching to the objectives and the content of a science

*TABLE 2: Examples of informal and non-formal forms of science education*

| Activity | Institution disseminating scientific knowledge | Informal form of education | Non-formal form of education |
|---|---|---|---|
| Museum activities | Science museums | Simple visit – excursion | Guided visit or educational project of several days |
| Activities related to science exhibitions | School, science clubs local administration, other organizations | Spontaneous organization without the guidance of specialists or educators | Organization with the educator's assistance or/and within the context of the curriculum |
| Participation in science labs | School, science clubs local administration, other organizations | Free activities without without the guidance of specialists or educators | Activities guided by specialists or educators or/and within the context of the curriculum |
| Research and Project work | Scientific and industrial places, school, other educational organizations | Simple visits, writing offhand reports | Writing synthetic/creative works with the educator's guidance or/and within the context of the curriculum |
| Bibliographical research | Press, radio, TV, websites, school libraries, other public or private libraries | Spontaneous reading audience, watching TV, surfing the Internet, constructing material patterns | Bibliographical research, construction of material patterns with the educator's guidance, use of texts, films, software in formal teaching |
| Use of spectacles | School, theatre, art studios | Watching theatrical plays, puppet shows, impressive demonstrations, telling and hearing stories | Use of corresponding activities in the process of formal teaching |

museum in contrast to an attempt to create a thematic typology of science museums. According to this classification, we can distinguish four categories of science museums (Koliopoulos, 2002):

(a) The *museum-institution*. This category represents a set of physical spaces especially set-up to facilitate people's visits. According to Caro (1996), there are three types of science museums – institutions: (i) the '*exhibition museum*', whose purpose is to gather, save, preserve, indicate and exhibit the natural, technological and industrial background of a science domain. The natural history museums, various university museums in Botany, Zoology, Paleontology and Physics as well as museums with collections of technological items (e.g. school laboratory instrumentation) are all examples of this type of science museum. Two large science museums in Greece, the 'Goulandri Natural History Museum' in Athens and the 'Technical Museum' in Salonica, operate,

mostly, as exhibition museums. (ii) The *'experimental museum'*, which promotes the active participation of visitors and attempts to familiarize them with the scientific knowledge through interaction, *experiencing* and *experimenting*. The effort here is for scientific knowledge to be appreciated through movement experimentation and sensory participation, the aim is to attain a better integration of the traditional science fields (Mechanics, Electromagnetism, Optics etc.) than is currently possible within school education. This refers to a type of museum attaining an educational character that can act side-by-side and even complementary to formal science education. Emphasis is given to natural phenomena and activity spaces rather than the exhibits themselves. The activity spaces usually have the form of galleries, places of experiment demonstrations (usually small amphitheaters), places for hands-on experiments or even spaces resembling to science labs. The 'Palais de la Découverte' in France and the 'Exploratorium' in the USA are typical examples of this kind of museum. (iii) The '*cultural centre*'. This refers to an open cultural center, where the visitor can approach the context of science without fearing that it might be too sophisticated for him/her. Exhibits and activities place emphasis on the social applications of science and technology. The aim is for the public to develop a positive attitude towards science and technology through appreciating their social utility. Scientific research is linked to industrial activity and, in general, the effort is to make the visitor aware of the scientific, economic, technological and cultural dimensions of the scientific enterprise. Instead of the traditional disciplinary organization, principally, one finds that cultural centers are organized along applied themes, such as Transportation, Communications, Space etc. 'Cité des Sciences et de l'Industrie (La Vilette)' in France is a typical example of this kind of museum. Experimental museums and cultural centers do not currently appear as autonomous organizations in Greece.

(b) *The virtual museum*. The development of new technologies, especially of the Internet, over the last decade has had a strong influence on science museums. Numerous museum - institutions have created their own Internet site to provide information on the available exhibits. Such sites can be used in two ways: (i) as an *information pool* and (ii) as *communicative means for developing collaboration*. Still, some researchers suggest the complete abolition or severe curtailment of big science museum – institutions on the grounds that they are unprofitable, inefficient organizations with inflexible administrative structures. In their place they suggest the establishment of autonomous virtual environments, liberated from the confinements of the buildings, geographical area and propriety establishment. Virtual museums are not currently developed in Greece, which

would be anticipated considering the existence of science museum–institutions is limited. This presents an opportunity for developing virtual sites for disseminating scientific knowledge independently of museum-institution.

(c) *The children's museum*. The children's museum is a place specially designated for the needs, interests, knowledge and psychokinetic abilities of young children. Traditional statements of the type 'look but do not touch' are surely unfit for children who prefer to learn through hands-on experimentation with real and virtual objects. Science museums presenting *interactive exhibits* and *experimental activities* are already close to the child's abilities and demands. However, certain institutions have proceeded in establishing autonomous exhibition areas, with specially structured material, instead of a simple sequence of interactive exhibits. These exhibitions are also suitable for pre-elementary children, which is not the case with 'experimental' museums. One of the best *science museums for children* is the 'Cité des Enfants', which occupies a large space in 'Cité des Sciences et de l'Industrie (La Vilette)'. In Greece we do not currently have such a museum but one can find some interesting science activities for children in other museums.

(d) *The museum-in situ*. This category includes science museums that only take meaning within the physical and human environment in which they were developed. A typical representative of this type of museum is the *open-space museum*. Such museums operate through functional connection with their locations and their historical context. At the same time, these locations are viewed as part of the cultural heritage and are, therefore, protected. Examples of open-space museums are the museums of moving water and museums near locations with interesting geological history. Another type of museum-in situ is the *university museum*. This includes real or virtual science museums run by one or more universities which serve part pf the research and didactical missions of these institutions. Finally, in this category of museums we could include the operating *industrial units*, which provide museum items, these are typically places of exhibition or purposeful educational activities related to procedures of transformation of scientific knowledge into the development of technological equipment. The apparent lack of science museum – institutions in Greece (and in many other countries of the Mediterranean basin- Demopoulos, 2002) makes these industrial units useful tools for any educator, whose aim is to promote the scientific and technological literacy of the students. In the same type of museum, one could also classify the science activities provided by different thematic museums. These activities, like conserving works of art or activities pertaining to folkloric approaches cannot be detached from the environment of their

development. For instance, the 'Greek Byzantine Museum' includes activities familiarizing the public with preservation methods for works of the Byzantine and meta-Byzantine era. In Greece, the science museum-in situ is, perhaps, the type of science museum with the greatest originality. This is because it potentially connects the development of scientific literacy, with local scientific and technological activity and not with items or ideas produced elsewhere.

In conclusion, despite the absence of a science tradition, the science museum in Greece exists. It can appear in various forms and become a source of inspiration for the design of non-formal types of science education at all levels. In the next section, we will specifically discuss how this objective can be achieved.

The interaction between science museum and school as a context for non-formal education: the potentials for Greek education

There are mainly two factors that influence the objectives and content of educational activities that can facilitate the synergy between school and museum. The first factor is the scope and variety of objectives that the specific science museum has adopted. It is for this factor that the analysis outlined in the previous sections can be useful to the educator. The second crucial factor relates to the *restrictions* imposed by the science curriculum. The school and the educators would have to handle these restrictions and correlate them with the opportunities provided by the science museum. The present article negotiates on the operation and synthesis framework of the two factors, from the school and educators' perspective.

A basic problem associated with the nature and characteristics of non-formal forms of education is whether and how the students can demonstrate progress in their knowledge in relation to the goals of the curriculum while visiting the exhibits and spaces of a science museum. Much of the existing literature concerning the educational role of the scientific museum focuses on motivation and learning in informal contexts such as scientific exhibitions or interactive exhibits (Ramey-Gassert et al., 1994; Science Education, 1997). These contexts have been related primarily with the '*casual visit*' or the 'g*uided visit*' (Koliopoulos, 2002). The casual visit is the most common method of approaching the science museum. It is hard to find a suitable educational context for developing a non-formal form of science education designated for the casual visit. The school and the educator have to try immensely to organize and adjust the visit to the school's curriculum framework. Usually, this does not occur and consequently the casual visit in a science museum results in a lost educational and teaching opportunity for the students, mainly because a combination of this lack of reference and sterile activism (Tunnicliffe et al., 1997; Griffin and Symington, 1997). On the other hand, many museums make an effort to substitute the casual visit with the guided one, they usually approach this by encouraging schools to

participate in specific projects organized by the museum. In the guided visit, the science museum assumes the leading educational initiative, in which case the actions of the educator are restricted to those of an escort or a person dealing with organizational issues and practical problems. In this context, any incompatibility of knowledge goals between the educational projects of the museum and the school curriculum can lead to stressful situations for school and museums alike.

Is it possible then to think of an appropriate educational environment for the enhancement of non-formal forms of education in the context of a school visit to a science museum? This environment that we would like to call a '*complete educational project*' must result from close cooperation between the science museum and the school. It must not also be identified and reduced to an isolated visit to the museum's spaces.  It consists of a complete dynamical procedure placing an emphasis on the phases preceding and following the visit. Both at the cognitive or the emotional level, the phase before the visit is quite important, bearing in mind that the educator, besides organizing the visit, must choose a topic proposed by the museum and *adjust it to the needs of the existing school curriculum and the cognitive abilities and interests of their students*. The phase after the visit is equally important. During this phase, there can be an evaluation of the project and construction of new knowledge based on the interests and emotions awaken by the visit. Essentially, this is the place that can *transform the popularized knowledge provided by the museum into a more structured and functional form*. In the complete educational project, the school and educator's role is to activate a procedure of re-contextualizing the scientific knowledge within the desired didactical transposition. This cannot be achieved by the museum. On the other hand, the science museum's contribution is that the students will experiment into new learning situations due to the variety of sources provided and will attain a better comprehension of the scientific, technological and industrial environment. The complete educational project brings us a step closer to achieving a wide range of cognitive, emotional and kinesthetic objectives, which promote the development of scientific literacy, since there is enough time for the mechanisms of popularization and didactical transposition to operate simultaneously.

The complete educational project can take several forms. In the following paragraph we will give two examples. The first example concerns the '*classe Villette*' project administered by the 'Cité des Sciences et de l' Industrie'. In this case, a group of Greek students visited and worked in the museum for a week undertaking a well-structured project. Educational projects, such as the 'classe Villette' project, are administered by local or international 'science museums–institutions' and engage teachers and students in long-term activities about a science theme or topic. The teacher is responsible to relate these activities with the

curriculum. The second example concerns an educational project on the production of wine that was designed by a group of researchers in the domain of scientific Museology and educators in early childhood education. This project, which is still in progress, includes activities before, during and after a visit by the children to the winery 'Achaia Clauss' of Patras, and aims to engage children in a process of actively changing their views about wine production. In this case, the school uses the 'museum-in situ' as a familiar and traditional place to establish valid scientific knowledge.

## Epilogue

It is only in the last decade that the relationship between formal and informal forms of education in science has become an object of research in Science Education and an academic subject of teaching. It is difficult for someone to identify consolidated methodologies or widely accepted theoretical frameworks to direct research or teaching in this area. Thus, this paper represents than a first attempt at describing an educational environment that is likely to create real interest and operational knowledge in science in the context of developing scientific literacy. We have traced epistemological differences between formal and informal forms of education in science and so introduced the term 'non-formal forms of education' to describe the type of educational environment within which there has been noted an excess of obstacles proceeding out of these differences. Hence, a relationship is established between the informal and formal character of education leading to scientific literacy development. Through a case study concerning the relationship of science museum and school, we have claimed that this relationship can become effective if it can take the form of a complete educational project, in which case the science museum and school can cooperate as equal partners. However, it must be remarked that the development of this relationship cannot be accomplished outside the cultural context it operates. For instance, the science museum concept is not homogeneous and it is not possible to assume the same meaning in a country that traditionally produces science as in a country, such as Greece, which for years has been receiving scientific knowledge from elsewhere. That is the reason why the desired scientific literacy is most certainly affected by the given cultural context.

Finally, this article raises more problems, than giving answers. This is indicative of the stage of development of this area of educational research. University research and teaching in the Educational Departments can help to further clarify the hypothesis that non-formal educational environments can blunt the tensions between formal and informal forms of education and lead to the

creation more of scientifically literate students and teachers. Specifically, a question, that remains open for future research is the following: What are the concrete cognitive and emotional outcomes of applying non-formal forms of science education in comparison to pure formal or informal forma of education forms? In the Mediterranean region, an interesting study could be designed aiming to explore differences and similarities in this topic between on the one hand countries having a rich tradition in science production and displaying many science museums and, on the other hand, countries that have been more on the receiving end science.

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# MEDITERRANEAN MODELS FOR INTEGRATING ENVIRONMENTAL EDUCATION AND EARTH SCIENCES THROUGH EARTH SYSTEMS EDUCATION

NIR ORION
ROSANNE W. FORTNER

**Abstract** – *Practitioners of modern environmental education frequently find themselves collaborating with those who are engaged in integrating the science disciplines in search of answers to natural hazard prediction/protection, understanding the deep sea and space, and especially confronting pressing environmental concerns with a basis in Earth sciences. Indeed, it is a lack of understanding of Earth systems processes and feedback mechanisms that has resulted in humans initiating or exacerbating environmental problems for centuries. In this paper the authors provide a perspective on the established fields of environmental education and Earth science, and propose a practical combination that is of larger global import as well as more personal relevance than either of the originals: Earth systems Education. The role of the Earth systems education model in integrating the science curriculum is discussed with regional examples from Israel and Cyprus.*

## The need for a new model

*A*t the start of the 21st century, more than ever before, there is a worldwide recognition that living in peace with our environment is more than just a slogan, it is an existential need. It is also agreed that the understanding of each of the earth's sub-systems and the environment as a whole is indispensable in order to live in peace with the environment. This understanding is actually what science is all about. As Dr. Jane Lubchenco, President of the American Association for the Advancement of Science, said in her presidential address to the organization in 1998:

> 'Fundamental research is more relevant and needed than ever before… adequately addressing broadly defined environmental and social needs will require substantial basic research… We can no longer afford to have the environment be accorded marginal status on our agendas. The environment is not a marginal issue, it is the issue of the future, and the future is here now.'

Accumulating evidence from academic research, historical records, modern community development, and political decisions in the first years of the 21st century points to the fact that most people do not have an accurate picture of how the fundamental natural processes of Earth function, or how their own actions relate to those processes. The magnitude of this problem indicates it could lead to global systems that are not sustainable for the future. A prime example is the reluctance of the U.S. administration at the start of the century to acknowledge the role of current U.S. policy and actions in the acceleration of global climate change. As a world opinion leader, but more importantly as a top contributor to the increase of atmospheric $CO_2$, inaction by the United States exacerbates this global issue. Global science literacy, based on integration of Earth sciences and environmental education, is key to addressing such problems in this and future generations.

*Environmental education*

It is suggested that the main purpose of environmental education is to bring students to understand the interrelations between life and the physical environment. Our future citizens should understand that life influences and is influenced by the natural environment. The natural environment is a system of interacting natural subsystems, each one influencing the other ones. They should understand that any manipulation in one part of this complex system might cause a chain reaction with dire consequences. The translation of these noble ideas to a practical educational plan is a very challenging task. Our view is that real understanding of the environment is based on understanding of its scientific principles and processes. The societal and technological aspects of this area should provide the relevant context for the study of the scientific concepts.

Environmental educators worldwide recognize their scope of work through a definition crafted in a 1969 conference in Tbilisi, Russia:

> 'Environmental education is aimed at producing a citizenry that is knowledgeable concerning the biophysical environment and its associated problems, aware of how to help solve these problems, and motivated to work toward their solution' (Stapp. et al., 1969)

Modern interpretations of these goals of knowledge, issue awareness and commitment to action take many forms, and a growing body of research is suggesting productive means of meeting the objectives. School science education is the source of the knowledge upon which hopes for environmental education depend (Fortner, 2001).

Environmental education should be an integral and indispensable part of the science curricula from K-12. Moreover, its critical necessity for our society, its relevancy to students' daily life, and its multi-disciplinary nature demand that environmental education should have an honored central place in the science curricula. The multi-disciplinary characteristic of environmental studies, their relevant importance and educational potential inevitably suggest that this subject should also be included with association to all the scientific disciplines.

*Earth sciences*

The world model for science education is based on disciplinary boundaries and traditionally sees a hierarchy that puts classical physics in the most influential position, followed by chemistry and biology. Most listings of the hierarchy stop with these disciplines as the critical ones, grouping remaining disciplines as 'Other,' without mention of the Earth sciences (Mayer and Fortner, 2002). Such an approach relegates to the bottom tier of science priorities those fields that study the way the planet works. It leaves to chance the opportunity to learn how to evaluate the risk of an earthquake, to understand how changes in a river's flow affect more than the amount of water it carries, or how changes in sea temperature relate to ocean current patterns, world weather, and the distribution of sea life.

In the United States only 3% of high schools offer a course in Earth Science, the most relevant venue for teaching about the way natural processes work. Such courses are more common in middle schools, but at both levels most textbooks separate the components into meteorology, astronomy, oceanography and geology, a convenient way to match the quarter-year grading periods but an impossible way to teach how critical subject matter is integrated. If such curricula were to be built upon the study of environmental issues, the natural processes of earth would clearly be shown as interacting systems. Two examples follow:

1) Fossil fuels' as a topic: lessons highlight their biological origins in Earth history, extraction from the lithosphere, combustion into the atmosphere, with resulting effects on atmospheric composition, climate patterns, biological responses (human health), and the like.

2) Watersheds' as a topic: lessons include the geological structures that shape the area, patterns of precipitation, erosion effects, protection of watersheds through development of vegetational buffers, importance of watersheds in distribution of pollutants.

The curriculum in Physical Geography, more common in schools of the Mediterranean, suffers from a lack of attention, as well as partitioning of subject

matter into disciplines, just as in the United States. What could be an integrated course at gymnasium level in Cyprus may be taught by several teachers with backgrounds in the more specific sciences of geology, physics, and such.

*Need for combining EE and ES*

Based on the issues noted, the traditional values of science teaching need to be re-evaluated in light of the needs of Earth inhabitants of the 21st century. Curriculum reform efforts throughout the world are looking at such evaluations, but change comes slowly without incentives. Sustaining the environment of the Mediterranean region should be incentive enough for change in regional curricula.

In the scientific community there are two main schools of looking at environmental studies. Both approaches focus on the interrelationships between humans and the physical environment, however they differ by their perspectives. One school is more concerned with the understanding of the physical environment, studying the five interacting Earth subsystems or spheres – atmosphere, biosphere, cryosphere (ice), hydrosphere and lithosphere. The other school is more concerned with environmental hazards from the human life perspective. This approach gives more concern to the interrelation between energy and environment, especially the exploitation of our limited energy resources and its effects on the environment. Human society, in this approach, is an integral part of the Earth systems. Technology has a dual role in the societal-environmental interaction. On the one hand, the technological revolution and the over-using of energy resources has dramatically increased the damage to some aspects of the environment, but on the other hand, new technologies can help in limiting environmental hazards and in providing alternative energy resources.

Research indicates specific needs for both of these perspectives. Using a systems approach has documented value in increasing understanding, and applies theory from wider research into the realm of education (Garigliano, 1975; Chen and Stroup, 1993; Hill and Redden, 1985; Lawton, 2001). In general, students, as well as college students and preservice teachers, frequently hold incorrect perceptions about Earth system relationships as well as how human activities impact those systems. Results regarding misconceptions are remarkably similar across education levels. The most common student misconceptions about climate change, according to a synthesis by Gowda, Fox and Magelky (1997) are:

– Inflated estimates of temperature change ($11^0$F/decade, compared to IPCC estimates of 0.5 F)

- Confusion between CFCs, the ozone hole, and climate change (ozone layer depletion causes climate change; stop using aerosols to prevent global warming)
- Perceived evidence – warmer weather (reportedly they could personally sense rising climatic temperatures or changes in long-term weather)
- All environmental harms cause climate change (aerosols, acid rain, even solid waste disposal)
- Confusing weather and climate

In many Mediterranean countries the way to teach about the environment is to have children in school groups plant trees and clean up rubbish from parks and beaches. While these are admirable activities, educators should question what is being learned that relates to making the child a globally literate citizen. The same children are likely to expect that their parents will drive them the short distances to the bakery or after-school lessons, and parents expect that doing so will make life better for their offspring. School science could be doing more to educate for the environment.

## Components of new models

In an era seeing a revolution in science education all over the world, education leaders and governments are seeing the value of providing a high quality of science education to all students, not just those who are college-bound. The first paragraph in the *National [U.S.] Standards for Science Education* (NRC, 1996) states:

> 'In a world filled with the products of scientific inquiry, scientific literacy has become a necessity for everyone. Everyone needs to use scientific information to make choies that arise every day. Everyone needs to be able to engage intelligently in public discourse and debate about important issues that involve science and technology. And everyone deserves to share in the excitement and personal fulfillment that can come from understanding and learning about the natural world.' (p.1)

As educational systems start to move towards this 'Science for all' approach, Earth systems Education should take a central place in the science curricula from K-12. This demand is based equally on the critical necessity of environmentally literate citizens for our society and the educational potential of this subject, namely its relevancy to students' daily life and its multi-disciplinary nature. Key components of the Earth systems Education approach include the following list.

*Integration*

In preparation for teaching an Earth systems/environmental education course for Cyprus teachers, author Fortner asked teaching colleagues to give a simple survey to a sample of students in a Nicosia lyceum and in the 9th grade in a U.S. high school. The students were asked to list the most important environmental issues in the world and in their own community. A review of the responses reveals the combination of science disciplines, human relationships, and technology aspects that go to make up the concerns of adolescents in the new century (Table 1).

*TABLE 1: High school students' perceptions of the importance of environmental issues*

| Cyprus Students (N=85) | | | U.S. Students (N=65) | | |
|---|---|---|---|---|---|
| Issue | World rank* | Local rank* | Issue | World rank* | Local rank* |
| Greenhouse effect | 1 | | Ozone hole | 1 | |
| Ozone hole | 2 | | Global warming | 2 | |
| Acid rain | 3 | | Overpopulation | 3 | |
| Forest destruction | 4 | 3 | Pollution | 4 | |
| Sea pollution | 5 | 5 | Oil spills | 5 | |
| Drought | | 1 | Endangering species | 6 | |
| Air pollution (exhaust) | | 2 | Using up natural resources | 7 | 2 |
| Rubbish | | 4 | Damage to the beauty and balance of the Earth | 8 | 1 |

\* Based on average responses to questions: What are the most important environmental issues of today's world, in order of importance? What are the most important environmental issues of our community, in order of importance?

\*\* Students struggled to identify issues in this clean, affluent community.

Are these students' concerns included in their science curriculum? Is the science in school serving all of them? It is clear that one science discipline, or even several sequenced in the curriculum, cannot address the breadth and interactive

nature of these concerns. Intentionally focusing on environmental issues as case studies for science learning could accomplish the desired connections and facilitate learning on a need-to-know basis (Mayer, 1995). Integration might be facilitated by development of appropriate textbooks, but at least in the U.S. such resources either do not exist or do not reach their potential for teaching Earth science in a holistic manner (Bixel, 2002). An instructional methodology that helps to facilitate integration is the use of concept maps as ways for students and the teacher to organize ideas and show the ways that disciplines are integrated in a topic (Novak, 1990; Zieneddine and Abd-El-Kahalick, 2001).

*Relevant local learning*

An often-quoted mantra of environmental education admonishes people to 'think globally, act locally.' This presupposes having something to think about! Without knowledge of the interacting systems of Earth, and the human place within them, individuals are unlikely to think beyond their own needs to their role in shaping the future of the global community. In its early introduction to the study of Earth systems science, the U.S. National Aeronautics and Space Administration (NASA) demonstrated the time and space relationships of integrated topics through a graph (Figure 1). The idea of the graph is that as the scale of time and space expands, topics become more integrated and more far-reaching in their impacts. At the origin of the graph are the here-and-now science topics that are immediately visible and relevant to learners.

Teaching children to learn about their own surroundings and the natural events happening there is not only scientifically sound, but also pedagogically correct. Teaching in the environment and using tangible natural events involves applying concrete operational learning styles. Piagetian theory would have us begin learning this way, moving later to the more global applications of concepts. It is more appropriate, then, to suggest that people 'learn locally, apply globally' (http://earthsys.ag.ohio-state.edu/ESE-webslide/slide10.htm). If those lessons are effective, learners may eventually be stirred to act locally as environmental educators would hope (Fortner, 2001).

Within this component of the Earth Systems model comes the value of the outdoor learning environment. The Earth systems approach places the concrete environment at the heart of the learning process. Therefore there is no doubt that any Earth system-based curriculum should emphasize the use of the outdoors as a central learning environment. However, the 'resources invested' in taking a class outdoors are very high in terms of organization, economics, logistics and safety. Therefore, the 'educational payoff' should be very high as well. It is suggested that the gap that exists between the high 'resources invested' and the generally lower

*FIGURE 1: Earth system changes over scales of time and distance: Climate example (simplified from Earth Systems Science Committee, 1988)*
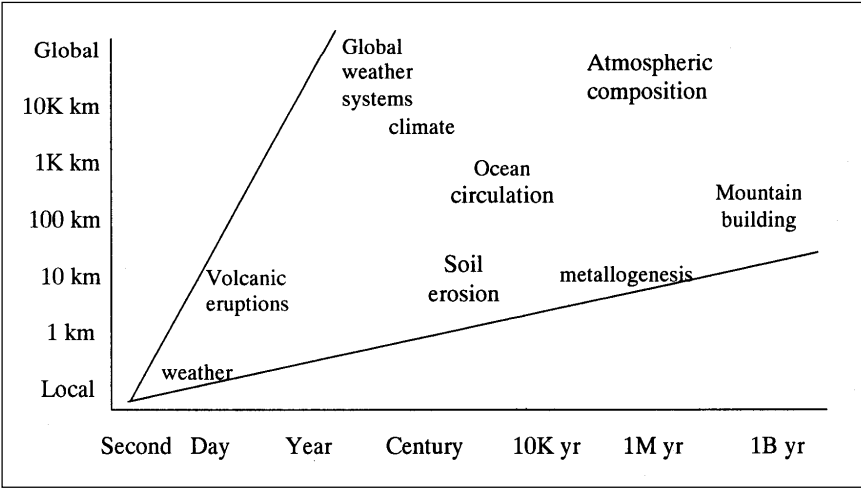
'educational payoff' is equal to the gap that exists between the high potential of the outdoor learning environment and its relatively limited fulfillment. This imbalance might be corrected only through a very clear definition of the unique educational contribution of the outdoor learning environment.

Orion and Hofstein (1994) suggested that the main cognitive contribution of the outdoor learning environment is in the concretization aspect. A more frequent use of the concrete-authentic outdoor learning environment might transform school learning into a more natural process for many children. However, the unique element of the outdoor experience is not in the concrete experiences themselves (which could also be provided in the laboratory and classroom), but the type of experiences. Students could view slides of a dune and investigate quartz grains in the laboratory, but it is only by climbing the steep front slope of a sand dune that a student could receive a direct sensori-motor experience of learning about the structure of a dune. Experiential (hands on) activities can facilitate the construction of abstract concepts and can serve as subsumers that enhance meaningful learning and provide the framework for long-term memory retention. Having stated this, one should be very careful not to cross the line between pedagogy and demagogy, since there is no way to teach abstract concepts such as the particle model, or the structure and function of cells through the characteristics of natural learning. However, in parallel to the many abstract concepts that any 21st century child of the developed world should know, there are

still many concrete scientific concepts and skills that can be learnt in the out-of-school world. As already noted by Kempa and Orion (1996), Kali, Orion and Eylon (2003) and Dodick and Orion (2003), even very abstract concepts such as the rock cycle and the hydrological cycle might be internalized if their study includes the concrete component of the outdoor learning environment. Orion (1993) argued that an outdoor learning event should be planned as an integral part of the curriculum rather than as an isolated activity. He suggested a spiral model where concrete preparatory units in the school together with subsequent outdoor events constitute a concrete bridge towards more abstract learning levels.

*Cooperative, collaborative learning*

Not only the subject matter of Earth sciences and environment, but also the processes of integration and application as human endeavors are teachable skills. Like integration of topics, integration of people's ideas is not commonly part of the traditional curriculum. Unfortunately competition, not cooperation, leads to academic success in a system based on testing for excellence in achievement.

Given that professional positions in science more and more frequently require cross-disciplinary activities and reliance on the expertise of diverse contributors, cooperative learning mimics life. In fact, the U.S. Department of Labor (1991) classified 'problem identification,' 'cooperation with working groups,' and 'finding information from diverse sources' as necessary skills for the new century. Earth systems education assists students who are normally competitors to identify for themselves a new role as a cooperator in seeking solutions to environmental problems.

> 'Imagine how different the world would be if people were taught from the first days of life that the sharing they do on the playground would also serve them well in creating a peaceful world and an educational system fostering human development in its most positive patterns! …in the learning of science, we can't all know it all, so why not share information, build each other's competencies, and grow together?' (Fortner, 2002)

Collaborative learning can also be the vehicle for integration of sciences. Student teams can be assisted in becoming 'experts' on disciplinary aspects of an issue. A study of oceanic ridges and hydrothermal vents, for example, might involve a group studying, then sharing, information about the life forms found at the vents, while other groups study the chemistry of the superheated water, the crustal movements that created the ridges and vents, and the patterns of density created by the hot, mineral-rich water. In reality, scientists from diverse disciplines

work together and no one scientist knows everything. Should every student be required to know everything, or is knowing multiple ways to access information the more lasting legacy of good science education?

*Enlightened leadership by educators*

Some curriculum reform efforts are being directed nationally by ministries of education, but top-down declarations do not foster meaningful curriculum change. Change happens inside the classroom, so teacher education and commitment to reform are necessities in reaching goals of educating in a systems approach. This 'grassroots' type of restructuring has been fostered in the United States through the Program for Leadership in Earth systems Education, which produced a guide for educators called 'Science is a Study of Earth' (Mayer and Fortner, 1995). The guide serves as a handbook and resource manual for teachers working to implement the integration, relevant learning, and collaborative classrooms that teach science by focusing on the Earth. It is used in on-line courses sponsored by NASA and in teacher education programs in a number of countries. The book provides suggestions on integrating disciplines within topics, in units of study or in whole courses, and identifies productive sequences of topics in integrated courses at high school, middle school, and elementary levels.

# Earth systems education in Israel

In an era of a revolution in science education all over the world, which starts to move towards 'Science for all' approach, Earth systems education should take a central place in the science curricula from K-12. This demand is based equally on the critical necessity of environmental literate citizens for our society and the educational potential of this subject namely its relevancy to students' daily life and its multi-disciplinary nature.

In Israel author Orion uses environmental issues as both a vehicle for learning scientific concepts and for organizing and implementing previous scientific knowledge. For example, the topic of global warming serves as a motivator for the study of chemical and/or biological processes that are involved in this phenomenon, and earthquakes serve as an advance organizer of learning about the earth crust. On the other hand, the carbon cycle is based on prerequisites of basic concepts in chemistry, biology and earth sciences.

Environmental case studies should be selected in relation to the relevancy of the phenomenon to the students' daily life experiences and its importance to the future of the humankind. Such case studies should be classified to three levels:

–   The local level
–   The national level
–   The global level.

The local case studies are varied from one locality to another. For example, air pollution is a very relevant topic for students who live in the Haifa gulf region, while floods are more relevant to other localities. One of the most important environmental subjects at the Israeli national level is the hydrological system. The greenhouse effect and the global warming debate are examples of global topics. In the Earth systems approach, local topics would be sequenced early in science experiences because of their relevance to all students, their here-an-now importance. As students grow in science knowledge and experiences, the more global and abstract topics will be appropriate in their curriculum.

Thus in order to fulfill the educational challenge, author Orion and associates have taken the following actions: locating of appropriate niches for the infusion of environmental or Earth systems oriented units in the curricula; research concerning teachers' and students' difficulties in teaching and learning subjects in an integrative manner (Ben-Zvi-Assaraf and Orion, 2001; Gudovitch and Orion, 2001) development of appropriate learning and teaching strategies; development of appropriate learning/teaching materials; and a massive inservice teacher education effort. The efforts have involved the professional scientific community in the curriculum development and in political support.


## Earth systems education in Cyprus

In the late 1990s there were already some efforts at science integration and incorporation of environmental topic areas in the schools of Cyprus. Several schools across the country participate in the environmental monitoring and data sharing of the GLOBE program (Global Learning and Observations to Benefit the Environment, *http://globe.gov*). Some lycaea were designated as pilot schools for teaching a course in Natural Science (Physiognostica), and the popularity of these courses continues to grow. Eco-Schools, encouraged and assisted by the Cyprus Marine Environment Protection Association, adopt curriculum innovations that introduce global environmental issues and local action to elementary students.

By 2001, plans for a teacher education program at the graduate level were being implemented in the University of Cyprus. As part of the curriculum conceived by Guest Editor Constantinou, teachers pursuing master's degrees in education could enroll in courses such as

**EDU 664**: Integrated Curricula in Natural Sciences. Physical and chemical systems and mechanisms. Modeling of phenomena and other approaches of integration. Reasoning abilities and scientific thinking. The development of conceptual understanding through integrated curricula (physics, chemistry, biology and technology).

**EDU 665**: Environmental Education. Earth systems. Interacting subsystems of soil, air, water and living organisms. The continuing evolution of geological systems. Ecosystems and ways of supporting and conserving them. The impact of human activities on the environment. The contribution of science and technology to environmental protection. Creativity in the design of curriculum materials for environmental education. Integrated approaches for developing environmental awareness, conceptual understanding and investigative skills.

With the Integrated Curriculum course, teachers explore topic areas that demonstrate how no discipline stands alone and all must cooperate to study environmental issues such as global climate change (where will the new Mediterranean shoreline be?), nonnative species impacts (*Caulerpa taxifolia*, for instance), and how ocean debris is carried to all parts of the world (origins of Cyprus beach debris). They develop classroom teaching activities that involve interactive learning, concept mapping to demonstrate discipline linkages, nontraditional education experiences (no lectures!), and available classroom technologies. One student project, for example, was a courtroom scenario developed for the Internet. In the simulation, students examined the impact of introduction of different types of trees into the Cyprus environment. One of the trees, a eucalyptus, was brought in to dry up marshy areas, and in modern day drought conditions the trees are now nuisances in the environment as they continue to draw precious water from the ground. Students using the simulation examine the tree characteristics, pictures of their habitats, water cycle relationships, and human needs, and decide if a tree is 'guilty' of damage to the environment.

With the Environmental Education course, the teachers examine theoretical and practical bases of curriculum integration, guidelines for excellence in curriculum materials (http://naaee.org/npeee/), and appropriate combinations of formal and nonformal experiences in the environment. They engage in classroom activities from Project WET and Project Wild, with emphasis on how topics of water and wildlife can be the basis for interdisciplinary learning in the sciences. The syllabi for these two courses as taught in 2002 are available from author Fortner. Projects developed by the teachers in both courses form the beginning of an alternative resource (non-textbook) set for teaching.

## Discussion and conclusions

The environmental-Earth systems education approach presented here is quite a challenging scheme. It involves the development of cross-curricular and cross-age programs. It involves interdisciplinary subjects and most of all it involves the teaching and learning about complex interrelated systems and the development of system-cyclic thinking.

Implementation requires finding the most appropriate teaching and learning strategies for achieving these goals. Since the scenario for science education, namely time for teaching, is very limited, an additional important challenge of science education will be to find the minimal scientific background needed for the development of environmental literacy. In other words, implementers must find a way to avoid being too shallow or too deep, and to stay in the natural systems level without approaching environmental advocacy.

In order to fulfill the educational challenge we recommend the following actions for innovators:

1. Develop a close relationship with the professional science community to assure their strong support. According the multi-disciplinary nature of the environmental studies, there is no single scientist who can cover all the aspects of this large domain. Therefore, one of the most important conditions for the development of scientifically sound curriculum materials is a strong scientific backing of a group of scientists who are specialized in different aspects of the Earth sciences and environment studies.
2. Together with environmental and earth scientists and science educators, try to define what global science literacy involves in the context of the local or national school system.
3. With scientific support advocate that the Earth system should serve as framework for 'Science for all' programs from K-12.
4. With assistance from leading teachers, identify those parts of the curriculum which can be taught in an environmental context.
5. Use the science education research tools in order to understand teachers' and students' difficulties in teaching and learning Earth system based curriculum.
6. Develop exemplary integrated curriculum materials for the science curricula from K-12. Teacher input is essential at this step as well.
7. Prepare teachers to
   a. assess incoming skills and knowledge of students, and plan to build on the results.
   b. focus on students' abilities and strategies in integration of concepts between different disciplines and within a single discipline

8.  Prepare teachers to:
    a.  use new curriculum materials and new learning environments such as the outdoors and the computer.
    b.  develop appropriate strategies for the implementation of multi-disciplinary programs and subjects.

The locating of the appropriate niches for the infusion of environmental or Earth systems oriented units in the curricula, the development of appropriate learning and teaching strategies, the development of appropriate learning/teaching materials, a massive teacher education program, and the strong support of professional scientists are already starting to have their positive influence on the quality and quantity of the Earth systems teaching and learning within the Israeli educational system. Implementation in Cyprus is in its infancy, but together the model for Earth systems education developed in these countries offers to other Mediterranean countries a real alternative in science curriculum restructure for 21st century relevance.

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# SOME PROBLEMS ENCOUNTERED IN THE INTRODUCTION OF INNOVATIONS IN SECONDARY SCHOOL SCIENCE EDUCATION AND SUGGESTIONS FOR OVERCOMING THEM

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**Abstract** – *This paper discusses some problems in innovating in the context of the school system in Catalonia and Italy. The process leading to reform of secondary education is briefly described. The issue of teachers' interpretations and reactions to the guidelines of reforms and innovations is focused on. For basic science education, two specific innovative teaching proposals about Energy and Motion/ Force are briefly described, together with a study of teachers' interpretations of their rationale and guidelines. The main transforming trends of these interpretations are discussed: these indicate that since teachers are major actors in the school innovation process, unless they internalise the proposed approaches, no real, successful implementation in classroom practice will take place. Finally, some guidelines and recommendations are suggested, which will interest education policy makers and teacher education agencies.*

## Introduction

*T*he many global changes that have taken place in recent years have questioned all the agents connected with education, especially the educational authorities, about the structure of the education system, the curriculum organization and the content of taught subjects. Consequently, curriculum reforms have been proposed in many countries. New perspectives coming from the areas of psychology, sociology, didactics and the use of ICT for educational purposes have often influenced the orientation of these reforms.

The educational systems in the vast majority of EU countries are involved in innovative processes, framed in the context of the 'knowledge society' scenario as outlined by the European Union Lisbon strategy (Lisbon European Council in 2000) and also linked to educational technologies. These opportunities go well beyond technical aspects, and not only affect the quality of disciplinary teaching and learning processes but also the development of capabilities needed in the new educational framework (e.g. learning how to learn is a widespread knowledge environment). The conventional roles, the rationale and many other features of

school education need to go through re-design and reforms: the aims are not only to improve learning of well acknowledged content areas but more importantly to foster effective and lasting learning habits and to make students capable of orienting themselves within the vast bodies of knowledge which are evolving rapidly in many contexts, both within and outside education.

However, reform and innovation depend heavily on the capability of teachers to evaluate, internalise and implement the proposed strategies and content; teachers' professional development is therefore an essential component in the process of redesigning education.

## School reforms

The processes of designing, spreading and implementing reform and innovation in school curricula and syllabi are usually long and complex, involving cultural, educational, political, sociological and economic factors. The following sections briefly comment on some recent reform efforts that have been implemented in Catalonia and others that have been proposed for Italy; subsequently, two examples of innovation attempts designed for secondary school science curricula are discussed.

### The case of Catalonia

Catalonia, a Mediterranean autonomous region within Spain, has been engaged in curriculum reforms since 1990-92. Responsibility for education in Catalonia lies not with the Ministerio de Educación y Cultura (MEC) (Spanish Central Government), but rather with the Departament d'Ensenyament de la Generalitat de Catalunya (Catalan Autonomous Government). The Catalan Government has full control over its educational system (since the LOGSE, Llei d'Ordenació General del Sistema Educatiu, BOE núm. 238 del 4/10/90) and establishes its own primary and secondary education curriculum, simply bearing in mind some minimal common core requirements.

With respect to compulsory secondary education (ESO - Ensenyament Secundari Obligatori), this competency is laid down by Decree 96/1992 in the DOGC (Diari Oficial de la Generalitat de Catalunya), which regulates curriculum development.

In Catalonia, a theoretical framework for school reform was elaborated by a commission of experts from different areas, the majority of whom are university teachers with different degrees of proximity to the school situation (Coll, 1986). The Commission established the epistemological, psychological and didactic

foundations of the new curricula, which underpin the syllabus for every discipline at each school level. The new programs for the disciplinary subjects are developed by external experts selected by the educational authorities; these are usually university teachers specialized in the discipline, or in one educational level. In drawing up a proposal (often elaborated individually) in accordance with the general framework, the experts rely on their professionalism, their educational experience and their knowledge of the school situation: Proposals are usually analysed and evaluated by other experts. Consequently, the content of the new syllabi is not outlined by commissions of experts and/or teachers for the different school levels, nor for the Service of General Inspection, as occurs in other countries. Minor modifications to the initial proposals may be made by the administration but, commonly, the plans are essentially accepted as the expert had drafted them. In recent years, a private version or a draft is usually circulated, with an invitation for in order to receive initial feedback from teachers. The next step is to make public the new program; this appears in the legal bulletin (Diari Oficial de la Generalitat de Catalunya, DOGC) and becomes official to all effects.

The Decree 96/1992 develops what is known as Primer Nivell de Concreció del Curriculum (First Level of Curriculum Specification). For each disciplinary area (including natural science, which comprises chemistry, physics, biology and geology contents) this determines:

a)   the general objectives of the subject area;
b)   the processes, concepts and attitudes considered as the content of the subject area;
c)   the ultimate objectives of the subject area.

The content of these 'first level documents' is so general that no explanation is provided of the specific objectives of each domain or of each theme. It is left to the schools and to teachers to establish autonomously the second level of specification, (sequence and modules) and the third level of specification (design of the materials and classroom action plan). Both levels of specification have to be within the framework of the first level of specification mentioned above.

In implementing the second and third level of curriculum specification, teachers very often follow the outline that educational publishers have adopted in published textbooks.

Some additional documents accompany the program; their main purpose is to clarify the objectives, to guide the teachers on how to teach globally, to elaborate on the priorities at each school level and to provide recommendations on how to organize and implement evaluation activities. These documents are not normative; they are published on the web site of the Education Department and are meant to offer advisory guidance and support.

*The case of Italy*

Reform of Italian secondary education has been under continuous discussion for about the past forty years and there is still no complete, coherent plan. Some of the key instances are reported here in brief. In 1997, the Ministry of Education announced a global reform of the whole school system, which had remained substantially unchanged for about eighty years (the overall rational being that of the 1923 Gentile reform). The Italian school system is the nation's biggest enterprise: about 90% of the schools are run by the state, and, in total, about one sixth of the population is involved. Since 1962, when a separate middle school was established for all curricula, very many changes have been implemented, but not set in a coherent framework, e.g. about 60% of secondary schools are engaged in various forms 'experimentation' with curricula and courses. The current situation is a school system where many initiatives of excellence coexist with many unsatisfactory situations.

The 1997 reform was based on: a review of what ought to be taught, a radical re-organization of the school cycles (primary, middle and secondary), significant increase in the administrative and didactic autonomy of schools, and a plan for development of educational technologies in all schools. To start implementing the reform, a board of forty 'sages' (acknowledged intellectuals, writers, musicians, university professors, religious representatives, some pedagogues, no school teachers) produced a 500-page framing document. This document emphasises the role of teachers and brings new tasks into play: '…teaching has to become a desirable profession once again, both culturally and socially, thanks in part to new career profiles….'. The main objectives adopted are: integration of disciplinary transmission within a network structure of knowledge; to foster acquisition of practical and operative skills (e.g. use of technologies); to aim at in-depth study of selected topics at each school level; to abandon the traditional scheme of lecture - individual study – assessment, in favour of learning environments based on communication technologies.  The first priority is to develop oral/written capabilities in Italian, and a functional knowledge of basic English. The main guideline for science education is to start from phenomenology-based learning and proceed to critical analysis of science and technological development.

Translating these criteria into official operational guidelines was the task of committees and workgroups organised by the Ministry of Education, in the framework of the re-organization of the school cycles and the new school autonomy; the latter was approved in March 1997. Since then several steps had been taken to make the reform plan operative (e.g.. science teachers' associations have proposed examples of a disciplinary syllabus;  proposals about specific aspects have been circulated and published in Ministry of Education journals and

on the website; committees have debated diverse viewpoints and come up with proposals, etc..). However, during this complex process a new government was elected in Spring 2001, which intends to implement radical changes to the reform process.

*Interpretation and implementation of proposed reforms and innovations*

In Spain, Italy and probably many other countries, the decision process about what will be taught is driven almost exclusively by experts. In secondary school, the program of each science discipline is usually taught by specialist teachers who often have well established teaching ideas and long experience in teaching the same or similar topics. In this content, the following questions arise: Will the changes introduced by reforms and/or new programs have any impact in the classroom? Is it easy, or indeed possible, to transfer the vision of the external experts to the practitioners trained in the field?

In recent years, studies about communication have received much attention and have emphasized the fact that in the process of transmission of ideas and information many transformations take place. The receivers are not passive agents; they reformulate and understand the information sent by the transmitter according to their beliefs, their preferences, interests, possibilities, etc. (Ogborn, 2002). This happens in all communication (written, oral, audio-visual, etc.) and can indeed have an effect on the transmission of curricular reforms.

So, it is worthwhile to formulate, and try to answer, the following research questions:

*How will official dispositions and legal guidelines elaborated by experts be interpreted by experienced teachers? How big will the gap be between the intentions of the emitters and the interpretations of the receivers? What order of magnitude of transformations happen between the communicated and the interpreted?*

Five research teams from five European countries have tried to answer this set of questions within a major research project funded by the European Commission, the STTIS project (Science Teacher Training in an Information Society). The project was coordinated by the Universitat Autònoma de Barcelona (UAB) and involved partners from the University Federico II of Naples, University Denis – Diderot of Paris VII in France, the University of Sussex in the UK and the University of Oslo in Norway.

The main hypothesis of STTIS is that, when a teacher implements a didactic innovation proposed by any external designer, that innovation is inevitably interpreted, re-structured, in brief 'transformed' (STTIS 1998, 1999, 2000a,

2000b, 2001a, 2001b). This inevitably happens since, in their school practice, teachers firstly experience logistic and curricular constraints and secondly are influenced by their convictions, beliefs and specific goals. Therefore, when didactic reforms and innovations are proposed, it is useful to study how teachers interpret the guidelines and the overall framework and how they adopt them in their specific contexts.

## The reform proposals

### The Catalan proposal about 'Energy'

In seeking to answer the above questions, the team from Barcelona elaborated a program, with the same format as the official curriculum, around one of the most common and problematic themes (Tiberghien, 1996, Warren, 1982) in the science curriculum for 14 year-old students in Catalonia: energy. Emulation of the official program was intended to enable analysis of the teachers' process of interpretation. In parallel, a booklet was prepared for the students who would be involved in this quasi-official program. Implementation of the program and any new teaching sequences became possible thanks to the Catalan teachers' autonomy to decide freely what and how to teach.

### The program

The objectives to be achieved by students regarding content (concepts, skills or processes and attitudes) were defined. Didactical orientations were added to guide implementation; these included an emphasis on some ideas, the approach to some concepts, difficulties that students would probably encounter and practical recommendations. 'The Program' comprises three aspects: objectives, content and orientation (Pinto and Gomez 1999): this corresponds to the usual way of presenting the first level of description in the National Syllabus in Catalonia (Departament d'Ensenyament, 1992)

### The didactical unit 'L'Energia'

Furthermore, a student booklet called *'L'Energia'*, was prepared (Pinto and Gomez 1999): this contained concepts, exercises and practical activities. All of this created a profile that perfectly defines the level and approach that teachers are expected to follow during classroom implementation; the implementation was expected to last for about 3 months.

*Problems to address and main features of the innovative strategy*

The scope of the innovative sequence is wide, and consequently the present research focuses on some specific parts. One specific problem, already detected in previous studies (Duit, 1981, 1983; Sexl, 1981; Ogborn 1986, 1990; Solomon, 1982, 1983, 1984, 1985; Pinto, 1993) is that students are unable to construct the concept of energy without a sound understanding of energy conservation (Saltiel, 1997), energy degradation and the relationships between the two. Some of the other problems that have already been identified are the following:

1. Teaching energy conservation linked to energy degradation and dispersal of energy is not very common in secondary schools (Kesidou and Duit, 1993).
2. Only studying ideal systems, as is usually the case in many introductory physics courses, does not allow students to conceptualise energy as a tool that is useful for analysing real situations (Arons, 1997, 1999). To be able to relate energy conservation with energy degradation, students should be encouraged to analyse their environment from a scientific perspective and to better understand better the everyday processes.
3. It is a very common procedure for teachers in physics courses to introduce mathematical formulae before analysis of any phenomena from a phenomenological or intuitive point of view (Reif, 1999). In other words, the real processes are remote from physics classes and, moreover, the nature of physics as a science is presented in a distorted manner.
4. Various, often non-scientific ideas about energy related topics frequently appear in the media (Driver andMillar 1985; Ballini et al., 1998). These are expressed in common language (with many deviations and differences from scientific language) and cover many everyday life situations. Energy consumption, waste, or expense, are common terms that may hinder the idea of Energy Conservation.

To address these problems, an innovative didactical strategy was developed for research purposes. The most innovative elements of the strategy are the following:

a. Organisation and the relationship established among the concepts differ from the 'traditional' line followed by most teachers and nearly all textbooks. For example, in the Unit entitled 'L'Energia', the concept of energy degradation is introduced as a decrease in capacity to do work, and dispersal of energy as the distribution among many particles, which is not the usual textbook approach. Another innovative approach is the establishment of links between degradation and the internal energy of the system (or self energy, after Alonso, 1971), or between dispersion and energy distribution among many particles

(molecular agitation) (Boohan and Ogborn, 1996). In addition, the energy degradation of a system is treated in the unit as a particular case of the general tendency of all spontaneous processes of nature (Ogborn 1976, 1986). Therefore, the interrelations are shown between energy degradation and the irreversibility of natural processes and nature's asymmetry.

b.  Discussions of phenomena and processes from different points of view, different theoretical frames and/or different levels of analysis (Pozo et al, 1991).
c.  Presentation of the same phenomena from macroscopic and microscopic worlds
d.  Didactical orientations and exercises aimed at establishing a bridge between languages or registers (scientific and everyday) (Solomon, 1983, Reif and Larkin, 1991).
e.  Considerations about the use of mathematical language in physics.

Other critical aspects of the innovation were defined but for the sake of brevity are not included here.

*Focus of our research: lines of analysis*

The teachers' reactions to the innovative aspects described above were analysed from two different angles (STTIS, 1999):

–  work with concepts: different organisation and different interrelations among them;
–  fostering the cognitive skills to be used by students when reasoning about phenomena.

Data analysis is guided by these two perspectives, and a qualitative methodology was used to detect teachers' reactions.

In order to obtain information about teachers' views of the teaching sequence presented in the program, 13 semi-directed interviews were carried out with the teachers of the sample (secondary school teachers from different Catalan state secondary schools).

*TABLE 1: Secondary school teachers interviewed.*

|  | Number of teachers |
| --- | --- |
| No knowledge of the booklet: 'L'energia' | 4 |
| Familiar with this didactical unit | 9 |

*Teachers' interpretations of the program and the proposal: main findings*

Here we report briefly some of the findings concerning the teachers' views of the program:

– Sharp differences were detected between teachers that had only seen the program and those that had also seen the booklet *'L'energia'*. A much better understanding of the purpose of the teaching sequence is demonstrated by teachers familiar with the booklet. Simply reading the program doesn't usually give a clear idea of its content. Teachers are reluctant to introduce concepts or innovative interrelations when they only learn about them from the programs (e.g. internal energy related with heat for secondary school students, coherent/ incoherent motion related to work and heat). Arguments about the impossibility of students learning these are common; however the teachers better understand and accept the innovations after becoming familiar about implementation from the booklet written for students.

– The novelty of the presentation or interrelation of the proposed concepts is sometimes not recognised; '*It (the new idea) is already taught usually without stating it explicitly*' is a common argument by teachers.

– Few teachers mention the interest in interrelating the different concepts of this conceptual field; for example, the interview results demonstrate the following:

• Failure to grasp the significance of relating work with heat, internal energy with kinetic energy, etc.
• Energy availability is very weakly linked with the capacity to perform work.
• The concepts of energy degradation and conservation are used simultaneously only by about one third of the consulted teachers.

– The intentions of the program can be misinterpreted when the conceptual meaning of the words is not well understood. For example, a very complex approach may be considered as very general if no recommendations about using mathematics are inserted. Without mathematics, teachers cannot fathom a great level of complexity.

– Some of the concepts are considered to belong to a specific discipline and cannot be explained within another one. For example, internal energy is considered a concept of chemistry that should not be covered in physics courses. Moreover, the concept of internal energy itself is often misunderstood and its use is screened by explanations in terms of heat and/or allusions to the complexity of this concept.

- The usefulness of introducing energy degradation is diversely perceived, sometimes only linked to «real life» and to debates about energy crises and renewable energies.

- Aesthetic considerations about the program have often been found in teachers' comments (e.g. 'integrating heat and work is very beautiful', demonstrating once again this frequently repeated reason for teachers to change their practice.

All these aspects of teachers' interpretation of the program prepared us for possible challenges that might arise during the implementation of the teaching sequence. Indeed, the predicted risks were confirmed when the program was put into practice.

After analysing class observations and video recordings, we detected ways of introducing the idea of energy degradation that are alternative to the one proposed by the didactical unit *L'energia* and are not acceptable from a scientific point of view. The proposal explicitly states the relationships between energy degradation, useful work, internal energy, heat, work and temperature. From classroom observations, it can be confirmed that, when teachers introduce the energy degradation concept, they do not usually draw on other concepts previously treated, unless it is absolutely necessary. Teachers do not explain the difference and interrelation between the concepts of heat and internal energy. Internal energy is called calorific energy or, more often, heat. These concepts are very often used in a misleading way when describing the energy transfers that take place in real processes.

A chapter of the didactical unit is specifically devoted to showing the interrelation between work and heat and, particularly, to showing that both concepts have a parallel status: processes of energy transfer providing equivalent outcomes (Atkins, 1994). During the implementation of the teaching sequence, we noted that both concepts are treated as two entities that are very different ontologically (Lederman, 1992, Desautels, 1998): heat is described as a kind of energy contained in the bodies or is used as the word to express internal energy (an idea already identified for in university physics students, see Pintó, 1993). It is not common to talk about 'losing energy as work' but rather frequent to say that 'energy has been lost as heat'.

In its content, as well as in its didactical orientations, the Program mentions the importance of language. It proposes distinguishing between the common and scientific registers of language and pointing out the meaningful differences in the terms that are common to both. Therefore, in the proposal to be implemented, the need to verbalise ideas is stressed through some specific activities that suggest shifting one word or linguistic expression from common registers to scientific language and vice versa. The intention was to help students to cross domains, to

establish a bridge between them, as pointed out by Solomon (1983). However, the response of teachers shows once again how the designer's intentions can be interpreted in different ways. Teachers' reactions to the sample of proposed activities and to suggestions about establishing a bridge between registers of language were in general, rather discouraging. Within different arguments, little effort was dedicated to crossing registers.

The above examples show some of the difficulties involved in implementing curriculum innovations, especially those developed by designers who are not in touch with teachers and/or do not have the opportunity to explain and clarify the deep reasons for the changes proposed and/or, the opportunities do not arise for teachers surmount possible weakness in their scientific background.

*The Italian proposal about 'Motion - Force'*

For many years the Naples University Physics Education group has carried out research studies about secondary school physics education (Sassi, 1992, 1995, 1996, 1997). During 1997-1998, within the framework of a National Project in Physics Education FISISS (FISISS 1997), the teaching proposal 'Motion and Force' (M+F) was developed (FISISS 2001, 2002); this is aimed at 14-17 year-old students. Since the Italian school system is a centralised one, the proposal has been tested in several secondary schools, at local level. (M+F) addresses three content areas: kinematics, force-motion and friction. These basic topics are usually taught in Italian secondary school physics courses and are also present in the syllabus recently proposed for the 1997 reform.

During 2000-2001, within the framework of another National Physics Education Project, SECIF, (Guidoni, 2001), the proposal was enlarged, optimised and re-designed, becoming a web-area known now as KINFOR (http://www.na.infn.it/gener/did/kinfor/secif/index.htm, SECIF 2001).

The main goal of the proposal is that of helping teachers become aware of learning difficulties commonly encountered by students on the topic of 'motion/force' and to become familiar with real-time lab-work approaches. The vast majority of physics teachers in Italian secondary schools have a university degree in mathematics and in their pre-service education they have experienced few experimental activities or none at all. This goal is achieved through implementation of a net of emblematic didactic approaches and paths addressing some crucial disciplinary and conceptual nodes of the motion/force topic in accordance with the official directions provided by the current physics syllabus.

This emblematic path starts from phenomena well known to students in terms of common-sense knowledge; both conceptual chains and sequences of practical activities are addressed (Balzano et al., 1992; Sassi, 1992, 1995, 1997, 1999). To

minimise the risk of interpreting the path's activities as recipes to be followed step-by-step, they are described as a 'script', the teacher and the class being the actors in the dynamics which will develop.

Attention has also been paid to 'crucial details' (Viennot, 2001). Examples of the paths' titles are: 'From regular walking to uniform 1D motion'; 'From rocking back and forth to the harmonic oscillator'; 'Inversion of Motion and Impulsive Forces'; 'Carts up/down ramps and falling objects'; 'Velocity Composition'; 'When friction is at work'. The time schedule suggested for each path is about 5-6 hours, consisting mainly of lab work in a small group setting to foster and support peer learning.

The main didactic features of the proposed rationale can be summarised as:

(a) focus on students' common learning difficulties (Carmichael et al., 1993, Viennot, 1996, Pfundt and Duit, 1998);

(b) emphasis on phenomenological observation, both through the exploration of experimental situations and the change-of-conditions (variational) approach (What happens if ….?');

(c) inference of regularities from the observed trends, to be checked through other experiments;

(d) experimental exploration based mainly on using Real-Time Experiments and Images (RTEI)[1];

(e) emphasis on the PEC (prediction-experiment-comparison) learning cycle; f. integration of diverse activities (such as lab-work, analysis of students' language, elicitation of prior ideas, relating data with models, etc.).

Since the proposal does not constitute a complete syllabus area, other than an overview of the rationale, it offers a set of materials to facilitate interpretation, such as: detailed suggestions for implementing the paths, Notes for Teachers, Students' Worksheets and a commented 'Catalogue' of real-time experiments discussing the main results typically achieved. In the framework of a constructivist paradigm (see for instance Joannert and Vander Borght, 1999), a set of criteria, hints and materials is also presented to help teachers design and implement their own classroom activities.

*The innovation instructions (In-In)*

To clarify the rationale, goals and didactic intentions of the proposal's example paths and materials, a list of Innovation Instructions (henceforth, In-In) has been produced. The aim is to help teachers compare their ideas, values,

habits with the innovation proposed and foster teachers' awareness of the innovation, and, finally, favour its adoption. To this aim, the In-In have been phrased in accordance with the indications for science education included in the above mentioned 1997 school reform. Underlying these In-In are several broad educational objectives, such as: to make explicit the capabilities and attitudes that should be possessed by teachers and whose transfer to students should be fostered; to call attention to teaching strategies made possible by the characteristics of RTEI.

Following is a summary of some examples of the In-In:

– The proposed didactic paths address the most common/robust learning difficulties in 'motion/force' area (e.g.. confusion between trajectory and the position vs. time graph; the negative sign of velocity and acceleration; motion inversions; correlation amongst kinematic representations of motion; velocity vs. position ('phase space') representation of motion; force vs. energy; impulsive forces in hits; transients and motion initial conditions; acceleration sign in the up/down motion of carts on ramps; elastic forces and oscillatory motion; Galilean composition of velocity and reference systems; friction as force; etc.)

– The paths regularly put into practice a rationale called 'from Real/familiar phenomena to Ideal case/models' (R-I). The suggested example paths start with (mainly real-time) experiments exploring phenomena familiar to the students so as to exploit perceptual knowledge and elicit intuitive ideas; they proceed by identifying regularities in the observed phenomenology which are then summarised in rules through 'cleaner' experiments (e.g. minimise friction effects in motion); they proceed by modelling these rules and moving toward abstract/ideal cases represented by simple mathematical models (textbook-like cases/models).

In order to achieve the above goals, the proposed didactic paths make use of the learning cycle 'Prediction - Experiment - Comparison' (PEC), both to help the students express their ideas and reasoning strategies and to ingrain the habit of integrating different types of capabilities.

Moreover, the paths focus on a 'perceptive approach', linking perceptual knowledge to abstract representations such as those of time graphs of physics variables; use RTEI (in this case motion and force sensors) mainly as cognitive tools and not merely as new pieces of lab equipment; implement a mixture of different activities such as real-time experiments, lab-work based on everyday materials, paper and pencil work (numerical and graphical exercises), teacher

presentation, etc..; encourage the students to become capable of describing the way RTEI works and explaining the main features of its hardware, software and data display; help the students become aware that, as with other experimental apparatuses, RTEI measures real phenomena; clarify that the data should not be expected to be 'ideal' just because a computer is being used.

*How teachers interpret the Proposal rationale and Instructions*

The reactions to the proposal of a group of secondary school physics teachers have been studied in the framework of the EU STTIS Project. A qualitative research methodology was adopted: a small sample of around twelve teachers were called upon to implement the proposal in their classes and their attitudes were observed (STISS 1999), while other teachers took part in a semi-structured, in-depth interview, based on a pre-established protocol. The interviewed teachers were: six from Italy, four from Spain, three from France. The Italian teachers had previously attended a 25-hour training workshop on the basics of both the proposal and RTEI (STTIS 1999). Two of the Spanish teachers knew the basics of Real Time systems, while none of the French teachers had any previous experience with them.

A specially designed booklet was produced that briefly describes the proposal, addresses content and related learning difficulties, outlines example paths, rationale and the (In-In), provides practical hints and a possible time schedule. The booklet was proposed to the teachers, who were later interviewed.

The questions addressed in the interview aimed at investigating teachers' opinions about the proposal: the main focus of the interview was that of having the teachers express their opinions on the features they considered 'innovative' and compare the way the content was presented within their normal ways of teaching. Moreover, the interview aimed at investigating the interpretations of the proposed In-In and discovering whether the features that the teachers found appealing suited them and matched the global didactic objectives. (Giberti et al. 2001, STTIS 1999) The process of the interview data analysis was analogous to the one used by the Catalan team. Two grids ('Lines of Analysis', STTIS 1999) were used to analyse the reactions of the teachers:

– Line of Analysis 1: Focus on learning difficulties and construction of concepts and reasoning strategies; emblematic paths leading from well known/familiar phenomena to abstract cases/models (from Real to Ideal).
– Line of Analysis 2: Fostering constructive learning through integration of different types of activities and focus on RTEI.

*Main findings and some suggestions*

Analysis of the interviews using the above grids allowed us to detect some teachers' tendencies. The results derived from the interviews with the Italian teachers showed:

(1)  A shared tendency to focus on and be aware of the need to introduce innovative teaching of Motion/Force and general discontent with the traditional ways of teaching this topic. Detailed discussion revealed that this awareness seemed to refer mainly to kinematics, and a little to the Introduction to Forces area. As to Talking about Friction, teachers showed some uneasiness, as if it was a 'difficult' subject and so they were not prepared to accept innovations; as one teacher said: 'Traditionally, friction is not studied in detail…while we always work on kinematics graphs…'. Only one teacher claimed: '... we usually disregard friction. It could be a way to do every thing all over starting from it'. In the framework of the 'Real to Ideal' rationale, Friction is a very important force to be considered; the proposed paths do not suggest a separation between a Kinematic description and a Dynamic one. The friction force is focused on every time one can see (in the Real Time graphs) its influence. Hence, the teachers' difficulties with this content area, probably linked to traditional ways of teaching this subject, do conflict with the Proposal's rationale, whereby the three content areas (Kinematics, Force and Friction) and the related paths are valued the same and no hierarchy is suggested, the focus being on addressing learning/teaching difficulties.

(2)  A shared  awareness about the need to elicit common-sense knowledge and to build upon it. On the other hand, when asked about what specific practical tasks in the proposal were suggested for reaching this goal, teachers could not respond adequately.

(3)  An awareness only of some parts of the two conceptual chains of actions and reflections underlying the proposed paths:  the Prediction-Experiment-Comparison cycle (PEC) and the 'from Real to Ideal' approach.

    3(a)  As regards the PEC cycle, none of the interviewees mentioned 'prediction' as a valuable tool for eliciting students' ideas and improving proficiency in lab-work, whereas they intended it as a motivating 'learning-through-discovery' approach.

    3(b)  As regards the 'from Real to Ideal' approach, all teachers, when interpreting it, focused mainly on the initial and final phases: exploration via Real-Time experiments and final presentation of the ideal case. The initial part of phenomenological exploration was

valued as a 'motivating' way to gain students' attention '…the students are enthusiastic... but mainly because they say that what is written in the textbook is 'ideal …'. It emerges from the data that weak teacher focus on the 'search for regularities and rules' and 'modelling' phases does affect the interpretations of the proposal rationale.

(4) The conceptual and practical chaining of the paths' activities was not a major teacher focus; they seemed to be uneasy about integrating the activities within the current classroom practice, probably because of various school boundary conditions and constraints.

(5) A strong focus appeared on the Real-Time experiments, but in most cases more as a way of motivating the students than to foster constructive learning: *'… for the students the use o*f computer technologies is very motivating…they were born with computers and are very good with them…they know computers better than me and this is also motivating…for them, it is part of their everyday life'.

As far as the Spanish and French teachers are concerned, most comments confirm the findings outlined above. The differences that appeared may be connected with various degrees of experience with Real Time systems, and  may depend on different curricular habits, e.g. a French teacher said: ' … for us, Kinematics is more a tool for studying other subjects than a goal in itself…'. Overall, some French and Spanish teachers claimed that the learning difficulties addressed in the Friction area are not as significant as those in the Force area or are not suited to the students' age group.

The 'triangulation' of reactions to the proposal from the Italian, Spanish and French teachers makes it possible to detect some 'transformations' of the proposal's rationale and of the In-In and allows us to outline some possible reasons. For the sake of brevity these are not discussed here (STTIS 1999).

The above analysis has confirmed that the ways teachers read/interpret written descriptions/instructions of didactic reforms and innovations are very important elements to be taken into consideration from the design stage onward. For instance, several interpretations indicate significant gaps with respect to the proposal rationale and its In-In.

Overall, a strong attraction toward old teaching habits is evident, for example: an inertial tendency to consider the textbook as the main reference even if the teacher is aware that its presentation may contradict with that of the innovation being implemented; a major concern about the actual possibility to implement lab activities and integrate them with traditional presentation; several 'de facto' difficulties in accepting activity based teaching and learning.

The willingness to adopt innovation appears strongly in the 'world of words' of these interviews, but, overall, the innovations seem to be perceived as scattered spots of 'fresh colour' on the 'old' teaching strategies.

On the basis of the above results, we can draw a number of guidelines and suggestions for education policy makers and teacher education agencies (the following list is neither in priority sequence nor exhaustive):

– The In-In need to provide detailed clarifications of the innovation rationale and to specify the educational and cultural reasons for the proposed innovation;
– In-In have to be phrased in such a way as to minimise the risk of their being interpreted as recipes to be followed; their set of orienting criteria needs to be followed by realistic implementation suggestions;
– Appropriate materials are needed to address this last matter;
– In the framework of a constructivist paradigm, the teachers need to be offered a set of materials aimed at helping them accept the proposed reform and innovation and to implement resonant class activities, including appropriate materials addressing 'dissonant' transformations which may occur in class practice;
– The In-In should address explicitly and extensively the way innovations modify, integrate and deal with the 'old' approach.
– The In-In should emphasise problems deriving from traditional teaching, for instance through commented examples of both students' learning difficulties, ineffective teaching strategies and textbook presentations;
– The In-In need to address explicitly the critical details of an innovative approach: e.g. the steps in the conceptual chain, the sequence and order of tasks that need to be accomplished. These critical features regard the internalisation and implementation of aspects which make explicit a coherent resonance with the rationale of the proposed innovation.

## Conclusions

The reported studies of the Spanish and Italian cases have shown that internalising school reforms and innovative teaching approaches requires broad acceptance of their rationale, coherent interpretations of their instructions and also the capability to implement them and exploit their potential in different contexts and situations. Teachers need constructive assistance in doing so. In order to adopt the reforms and the innovations successfully, teachers also need to be supported in becoming aware of why they have been proposed and of the problems in traditional teaching approaches that need to be solved. Therefore, the rationale and instructions should be designed and presented so as to take into account teachers'

views, convictions, beliefs, interpretations, experiences and ideas about didactic innovations.

It is not enough for educational researchers to present their proposals and support them on the basis of results obtained in the research framework (STTIS 2001b). Every day teachers experience the details of their specific practical, logistic and professional situations, therefore, the adoption of any reform and/or innovation depends heavily on them. In order to facilitate take-up of reform and innovations, it is necessary to offer teachers support materials and emblematic training situations that can help them to internalise the reform/innovation proposed through careful analysis of the teaching strategies they normally adopt and of the shortcomings entailed in following them. An experiential approach is a powerful tool for comparing the 'old' with the 'new' in order to fully adopt a reform.

Educational researchers involved in designing didactic innovations also need to call attention to possible (observed) interpretations and transformations of In-In made by teachers implementing innovations in ordinary conditions, so as to clarify what a take-up process implies and to support/facilitate adoption. Thus, policy-makers should foresee the implementation of appropriate teacher training programs devoted to favouring the take-up of0 innovations and also take into account research-based recommendations.

This situation, far from being specific to our samples in Italy and Spain, has also been observed by other partners in France and the United Kingdom who were involved in the STTIS project: distortions of what official dispositions tried to say should be taken into account.

So we propose that any change included in a new program should be articulated and justified. In many cases, we have found that teachers would need specific training but the most significant matter is to clarify the reasons why there is a need to modify the traditional way of presenting a concept, a sequence and a content area. If we consider that continuous teacher education should largely be reflected in practice (Gunstone, 2001; Pinto 2001; Sanmarti, 2002), teachers make explicit the reasons that made the traditional teaching of a particular subject incorrect, inappropriate or ineffective. It is not sufficient to plan courses aimed at global introduction of curriculum reforms and/or innovations that focus mainly on description of intentions, or courses that focus exclusively on getting teachers' reactions on them. What should be done, in order that the new curricula be implemented, is to plan specific teacher training courses founded on a socio-constructivist framework and on meta-cognitive views. This approach could help to:

– raise teachers' awareness of previous ideas not only about learning processes but also about what is implied by different ways of teaching;

- elicit teachers' own specific conceptual ideas about the scientific subject to be taught and their ideas about problems in teaching it;
- comparing the new approach with the old one so as to highlight the reasons for the change; why should the old approach be criticised and, especially, what can be gained with the new one.
- raise awareness of the use of language in science learning, after recognising what are semantic changes and what are conceptual ones.

In conclusion, in-service teacher education courses need to offer teachers the opportunity to reflect on their own conceptions about the innovative aspects of a program in a way that leads them to accept the new formulation as a better one with respect to the old. In order curriculum reforms and/or innovations to be introduced effectively, it is worthwhile to teacher education initiatives that also rely on research results.

## Notes

1. Information on Real-Time systems can be found at: www.vernier.com; www.pasco.com; http://www.cma.science.uva.nl/english/index.html. Here we refer to MBL (Microcomputer Based Laboratory), developed by the Centre for Science and Math Teaching, Tufts University, Medford MA 02144, USA (R. K. Thornton, Director).

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# TEACHING AND LEARNING SCIENCE IN PALESTINE: DEALING WITH THE NEW PALESTINIAN SCIENCE CURRICULUM

NADER ATALLAH WAHBEH

**Abstract** – *Since the establishment of the Palestinian Curriculum Development Centre in 1995 and the development of the First Palestinian Curriculum Plan in 1996, the Ministry of Education has introduced, for the first time in Palestinian history, textbooks for grades one, two, six, and seven. The need for a comprehensive evaluation process for these new curricula has been highlighted by many Palestinian intellectuals, thus questioning the efficacy of the technical approach followed by the Ministry of Education. In the first section, the paper briefly outlines, the specific challenges and tensions in teaching and learning science in the new Palestinian curriculum. I examine the complex history of science education in Palestine during the Israeli occupation and illustrate how the occupation has contributed to the above challenges and tensions. In the second section, the paper discusses the vision adopted by the Al-Qattan Centre for Educational Research and Development (QCERD) which takes an approach to curriculum evaluation and research from socio-cultural perspectives. This vision views the science curriculum as process and praxis, and focuses on what occurs in Palestinian science classrooms. It involves working directly with science teachers at the pre-service and in-service levels, in order to encourage reflection, dialogue and critical inquiry. In the third section, the paper presents the results of ongoing research projects carried out by QCERD concerning curriculum evaluation. Taking the Palestinian school as a unit of analysis, and the science classroom as a laboratory in which each teacher is a researcher, educational theories are translated into a hypothesis that is testable in practice, and the science curriculum is developed and evaluated through a dynamic interaction of action and reflection. Additionally, the paper focuses on how science teachers mediate the overt science curriculum as well as the hidden curriculum, which is embedded in the daily interactions and regulations of school life. I argue that the science curriculum transmits authoritarian knowledge and values by placing the teacher at the center of the educational process, and by neglecting competencies that are necessary for democratic practices in the classroom. The paper concludes by offering a set of concrete policy recommendations about the importance of involving teachers in the process of curriculum evaluation in a way which empowers them as practitioners to reflect on the norms and values that are being presented in the science curriculum and the Palestinian curriculum as a whole.*

## Introduction

*M*ost science teachers in Palestinian schools are graduates of the science and the educational science departments in Palestinian universities and colleges. There are eleven universities and five colleges in the West Bank and Gaza that offer Bachelor degrees, ten of these universities and two of the colleges offer a Bachelor degree in science (i.e. mathematics, chemistry, physics, biology, and computer science) and science education (i.e. science subjects together with teaching pedagogies, teaching methods, counseling, curricula, management etc.). Some universities and colleges offer a diploma degree in education and science teaching to pure science students as a minor degree, and to in-service science teachers who seek teaching certificates.

Many of the Palestinian universities have recently introduced graduate colleges and departments, which offer a Masters degree in sciences and in education, and most of its students are from the in-service sector, including science teachers (see Table 1).

*TABLE 1: Distribution of graduates by colleges, Department of Science and Education and degrees offered in the year 2001/2002.*

Ministry of Higher Education (2002*) Statistical Year Book 2001/2002*, Ramallah, Palestine.

\* M.A=Master Degree, B.A= Bachelor Degree, H.D=Higher Diploma, D=Diploma.

In general, most existing institutions of higher education were established during the Israeli occupation by Palestinian individuals and group initiatives, mostly with the support of the Palestinian Liberation Organization (PLO), and with financial contributions from Arab countries. These institutions, together with other educational institutions in Palestine, suffered under the Israeli occupation: repeated closures, military checkpoints, frequent arrests of students and staff, and imposed economic constraints (MOHE, 1997). While the curricula of the pre-university education institutions were under thorough censorship by the Israeli civil administration, the Palestinian higher education institutions were able to maintain their independence, regarding educational programs and curricula. As a result of Israeli occupation measures, these institutions became highly politicized and played a major role in promoting democratic practices in Palestinian civil society: generating public debates, organizing programs of political discourse and resistance, and creating political and intellectual figures who eventually took part in the social and political decision-making processes of the society.

Following the 1993 Oslo agreement, many Palestinian areas in the West Bank and Gaza Strip came under Palestinian control[1], while others remained, remain under occupation. The Palestinian National Authority (PNA) assumed control over the educational system in the West Bank and Gaza and, in 1996, it established the Ministry of Higher Education (MOHE), transferring the mandate of the Council of Higher Education, which was responsible of managing the entire 'post-secondary' education sector until then, to the new Ministry. Meanwhile, most of the 'pre-university' education sector became the responsibility of the Palestinian Ministry of Education (MOE) set up in 1994 (now responsible for over 74% of the schools with 653650 students and 28015 teachers). The other pre-university institutions continued to be the responsibility of the United Nations Relief and Works Agency (UNRWA) (over 14% of the schools with 244711 students and 6946 teachers), and of the private sector (nearly 12 % of the schools with 55121 students and 4376 teachers) (MOE, Educational Statistical Brochure 2001/2002).[2]

In spite of the 'consumer-producer' relationship between the two Ministries (MOE and MOHE) (Sanyal, 1999), by which the MOHE is the consumer of the pupils graduated from MOE, and the MOE is a consumer of the products of the MOHE institutions in the form of teachers and administrators, these two ministries worked and are still working separately in developing their visions and plans. This lack of coordination has led to many problems in the two sectors, and has affected the quality of the pre-service and in-service science teaching programs, and the science teaching profession as a whole.

Concerning the higher education sector, the MOHE is now making serious efforts to improve the critical situation that the Palestinian universities and colleges have reached. Recent reports show that science education programs in

Palestinian universities as well as other programs are facing difficulties at the policy as well as the program quality level. In their report, Hashweh and Hashweh paint a 'gloomy picture' of the state of higher education, indicating the system is nearly on the verge of collapse. They describe the problems in these institutions and show that there are 'difficulties in implementing policies and regulations in a situation characterized by lack of proper administration, planning and policy setting' (1999: 223). Furthermore, results of an evaluative study conducted by the Al-Qattan Centre for Educational Research and Development (QCERD, 2001) are consistent with those of Hashweh's: the duplication of field of specializations and programs, the absence of admission criteria agreed upon by the institutions, and the lack of human resources, together affect the quality of the higher education programs in Palestine. In addition, the QCERD report and the annual report from the MOHE (1997) reveal serious problems with the education programs offered to science students. Many programs are overly theoretical, irrelevant to Palestinian social and economic needs, and neglect the practical dimension of real school settings. These programs do not serve the different school tracks and levels and their curricula are not matched to the needs of Palestinian science teachers. In its defense, the Palestinian MOE inherited an educational system in a state of disrepair caused by the Israeli Occupation. In 1994, the MOE took responsibility for most of the pre-university education sector, and planned to reform the educational programs through its five-year developmental plan. The plan's main objective was to improve the professional quality of teachers through in-service teacher training programs, to develop staff administrative skills, to support the supervision system, and to strengthen cooperation between the Palestinian education sector and the international community. Science graduates who worked in the teaching profession without teaching certificates were obliged to obtain at least a diploma in education or in teaching methods from a university. All teachers, including science teachers, were enrolled in extensive developmental training sessions and workshops during and after school hours.

The MOE assumed control of curriculum matters after establishing a 'Curriculum Development Center (CDC)' which replaced the curriculum committee that worked for nearly two years to produce the first draft of a curriculum plan. New textbooks were introduced in September 2000 for all subjects, in grades one, two, six and seven, thus replacing the Jordanian and the Egyptian textbooks that were used in the West Bank and Gaza during the period of the Israeli occupation.[3] This process will continue until new texts are generated for all grades in all subjects.

Recent statistics indicate that there have been general positive changes in the Palestinian educational system, especially in the year 2000 before the second Intifada began. The illiteracy rate for individuals 15 years or older in the West

Bank and Gaza Strip dropped to 10.8% compared to 13.9% in 1997. The number of schools and kindergartens increased to 2646 in the year 2000 compared to 1910 in 1994/1995. Declines in elementary level dropout rates, increase in female enrollment in schools, and decrease in student/teacher ratio are all examples of improvement in the education sector has improved since 1995 (Palestine Economic Policy Research Institute-MAS, 2002).

Despite the positive changes, the quality of teaching and learning in Palestine is disappointing. Today, science in-service teachers are highly demoralized by the centralized bureaucracy and strict hierarchy of the school system run by the MOE. Furthermore, with the Palestinian economy in collapse, and with the low salaries of the teaching profession and the increase in costs of living, many science teachers seek additional income through afternoon jobs, leaving no time to attend the afternoon training programs offered by the Ministry of Education. Due to the current salary scales, men are leaving the teaching profession, while women are beginning to fill their positions. The noticeable increase in the numbers of women in the teaching profession can also be attributed to the positive social changes in Palestine which allow more women to study and to work (Graham-Brown, 1984). Due to the very high population growth among Palestinians and the tremendous increase in student enrollment at both the primary and the secondary levels, the MOE has given its priority to building schools and renovating existing ones, rather than improving the quality of education (Hashweh, 2001; Rihan, 2001). According to Hashweh, the MOE is grappling with the quantitative problem of providing education for all, rather than with improving the quality of education' (Hashweh, 2001:361).

The outbreak of the Second Intifada in September 2000 and the ensuing escalation of the conflict with Israel have led to severe deterioration of the education sector in Palestine. Many schools have been forced to close because of Israeli sieges and incursions. The reoccupation of the Palestinian territories and the curfew imposed on population centers by the Israeli military has made the situation even worse. Palestinian MOE reports indicate that since the Second Intifada began, 212 schools have been forced to halt operation due to Israeli measures, either because the schools were turned into military camps, or were closed for other reasons due to Israeli military orders. This number has increased since the incursions of May 2002, now totaling 1289 closed schools (MOE, 2002). The MOE has adopted several measures and developed an emergency plan to maintain the educational system. These measures include assigning teachers to schools in their area of residence, recruiting university students, administrators and volunteers to substitute for the sudden shortage of teachers, relocating students to study in their local schools, etc.

The higher education institutions are also suffering in the current situation. Many students and teachers have been unable to obtain access to their universities

and colleges because of the tight Israeli siege. The MOHE has also taken several measures to guarantee the continuity of education in universities and colleges. Some of these measures include allowing students to join courses in other universities closer to their place of residence, extending the term by reducing summer vacation, moving courses to locations outside university campus, and finally, using the internet as a communication tool between students and teachers, which is considered by many observers as a positive step toward self-learning.

In the following section, I will describe the Palestinian Curriculum development process and suggest the need for a new vision of curriculum evaluation. A comprehensive evaluation process illustrates that the new Palestinian curriculum does not succeed in fulfilling the Palestinian need for a democratic discourse.


## The Palestinian curriculum development process

In the 1990s, calls came from leading Palestinian educators to include aspects like democracy, citizenship, multiculturalism, and the right to difference in the new Palestinian curriculum. Brown (2001) speaks about three distinct groups through which the new vision emerged: the first group was those Palestinian intellectuals who worked in educational issues but were not academic specialists in education. Their desire was 'to build a more participatory and democratic national culture,' and their focus on democracy became a priority after the creation of the PNA. The second group described by Brown is the educational reformers who shared a critical view of existing educational practices. Their major focus was to develop and apply theories in order to create active, critical, and reflective learners and practitioners. The third group of reformers, according to Brown, consisted of teachers who gathered on educational or political bases, and became active during the first Intifada (1987-1992). Afterwards, some of these groups took a step forward and formalized their activities under nongovernmental organizations and began to focus on teaching pedagogy, methods and social issues such as democracy, identity, and citizenship.

Among those intellectuals of the first group was the late Ibrahim Abu Lughod, a Palestinian political scientist. Abu Lughod led the first politically independent curriculum team and worked with well-known academics and produced a plan for Palestinian education that emerged from extensive consultations with teachers, students, parents, academics and members of the business community (The First Curriculum Plan, 1996). The concept of a 'democratic classroom,' introduced for the first time in the Middle East by Abu Lughod, was one of the innovations based

on a model of social interaction and democratic decision-making processes (Moughrabi, 2002). Brown and Moughrabi explain that this model places the role of the student at the center of educational processes rather than as a 'container of knowledge,' and reconceptualizes the role of the teacher to be a guide and a facilitator of critical thinking through group work, experimentation, case study and other instructional techniques. This requires, according to the plan, 'empowerment' of teachers and students. Teachers must be prepared to be life long learners, and participants in the decisions made concerning curriculum development and policy-making (Brown, 2001; Moughrabi, 2002). At the same time, students must have the opportunity to question, speculate, wonder, and challenge, without the fear that they may give the wrong answer. 'Without confidence in their own abilities to think and question, they will not be equipped to participate actively in other democratic institutions and processes' (Al-Haj 1996: 229). In addition to the emphasis on democratic education and the promotion of critical thinking, the curriculum plan also makes many key recommendations: more focus on producing an identity that is open to other cultures; more emphasis on teaching ethics, expanding the school schedule; abolishing the final matriculation exam known as the Tawjihi, and adopting student achievement in all the three stages of schooling as a criterion for school graduation; replacing the school inspectors with school supervisors and eliminating the tracking of high school students into students of scientific and literary streams.

With respect to the science curriculum plan, the Abu Lughod team proposed a curriculum that transmits relevant, interdisciplinary and integrated knowledge and skills, especially in the technical fields. Inquiry must be the basic approach to teaching science at all levels; questions which enhance creative thinking should be asked and worked on through investigation and experimentation. The plan presents the general objective of science teaching for both the primary and the secondary levels as follows:

1. Becoming acquainted with the Palestinian natural environment and its relationship to humans.
2. Realizing basic scientific knowledge in all disciplines and implementing it in 'the real world'.
3. Acquiring scientific thinking skills and applying them in solving scientific problems in real life.
4. Realizing the importance of science and technology in human lives.
5. Realizing the role of scientists in the scientific development process and human civilization.
6. Enhancing creative thinking and scientific imagination.

7. Realizing the relationship between science and mathematics to technology and other disciplines.
8. Enhancing self-learning and inquiry skills.
9. Acquiring the skills necessary to use science equipment in an effective way.
10. Acquiring scientific attitudes and values.

The CDC created by the MOE which replaced the curriculum team led by Abu Lughod neglected the teams' recommendations, and formulated its own approach (Brown, 2001; Moughrabi et al., 2002).

The CDC developed a curriculum plan and identified four foundations for the curriculum (Intellectual and national, social, cognitive, and psychological. The general four foundations of science teaching originated from the four main foundations and can be summarized as follows (MOE, 1998: 5):

1. Intellectual foundation: The science curriculum seeks to reinforce faith in God, reflection on the universe, the embodiment of 'good' human values and principles, to reinforce the status of mind, to promote the importance of the role of technology and science in developing society and human civilization.
2. Psychological foundation: The science curriculum takes into account the learners' needs, his interests, and his cognitive and physiological characteristics. It also encourages the learner to participate in activities of self-learning and group learning taking into account individual differences, and establishing rules of 'comprehensive experience' in personality building.
3. Social foundations: The science curriculum should strengthen the ties between the learner and the society, and enhance the individual understanding of environment and her/his ability to play an active role in preserving it, solving its problems, as fit to the Palestinian society.
4. Cognitive foundation: The science curriculum takes into account the nature of scientific knowledge, its 'structure', and the relationship between science and technology. It should emphasize the importance of research and cognitive thinking.

These foundations according to Rihan are comprehensive and ambitious, and require vast human and financial resources and political stability. Rihan expresses his concern regarding the MOE curriculum plan, starting that they may be 'overly ambitious' in a sense that they 'could end up being nothing more than a new packaging of old wares' (2001: 29).

The new Palestinian curriculum has culminated in a set of textbooks assigned to single academic subjects, such as Arabic Language, Mathematics, History, Science, etc. The MOE and its CDC introduced for the first time both civic and national education curricula, a step that was considered an important innovation

among most Palestinian educators. However, studies on Palestinian curricula in general reveal that the textbooks are homogenous curricula that are fundamentally similar in their philosophy and approach to many traditional curricula used in different countries, i.e. they take a technical approach based on the assumption that a curriculum can best be evaluated by determining its results. Al-Ramahi and Davis, in their study on primary education in Palestine, have found that ' the new curriculum is highly classified by different experiences, skills and subjects, where each subject kept its status in the hierarchical order of knowledge, at prescribed times, using subject-based textbooks' (2002: 68). The MOE, in fact, imposes an educational system that is quite similar to the one that exists in various other Arab countries: rules that rest on a narrow social base, bureaucracy and an authoritarian approach to management. The centralized educational system where practitioners enjoyed little autonomy was, according to Al-Ramahi and Davis (2002), the main reason for hindering the process of implementing the integrated-learning project and a child-centered approach.

An example of the way in which the educational system is traditional can be seen in the authoritarian role of science supervisors. Focus group discussions carried out by QCERD with teachers and students reveal that the top-down instructions of the training programs held by the Ministry supervisors, especially those training programs concerning the new science curricula, are frustrating because they are compulsory yet irrelevant to teachers' realities and insufficient to change teachers' beliefs and practices (Khaldi and Wahbeh, 2000). Even though the MOE has devoted considerable time and effort to improving the supervisory system, science teachers still view the Ministry supervisors as inspectors who visit teachers once a year detecting weaknesses rather than to help and improve their teaching skills (Khaldi and Wahbeh, 2002).

The above aspects of the curriculum indicate that there is a need for further evaluation. The QCERD is an independent Palestinian research institution established in 1998, and its primary mission is to improve the quality of teacher education in Palestine and to empower the Palestinian teacher to improve her/his teaching qualifications, and to provide teachers with the opportunities to become researchers and reflective practitioners through action research. The Centre perceives its mission as one which is complementary to the work of official and unofficial institutions such as the MOE and non-governmental organizations and universities which are actively involved in planning and providing educational services. The QCERD recognizes the role of the teacher as a producer of knowledge through her/his research, and as a key player in the curriculum development process. Upon production of the new Palestinian textbooks, the QCERD research team responded to public and institutional calls for a comprehensive evaluation of the new Palestinian curriculum.

*Rationale*

The QCERD, adopts Apple and Beyer's (1998) theory of the social evaluation of curriculum. Our evaluation views the science curriculum as process and praxis, focuses on teacher student evaluation and involves working directly with science teachers at the pre-service and in-service levels, thus encouraging reflection, dialogue and critical inquiry. According to Apple & Beyer, the social evaluation of curriculum enables teachers and educators to discover the lived experience of students, and reveal why curricula fail and why programs are accepted or rejected. This approach to evaluation addresses the power of the official knowledge imparted through specific discourses, and provides realistic answers to important questions such as: 'whose knowledge is presented in the curriculum? Who selected this knowledge? Why is it organized and taught in this particular way? Is this what parents and educators really want? What are the social impacts of this knowledge?' (ibid, p: 342).

In contrast, the technical approach that was adopted by the MOE places emphasis on the process/product rationale, one that relies on measures of students' achievement of scores and on pre and post-tests to evaluate the curricula and its efficiency. Willis (1988) elaborates on the technical approach to evaluating the curriculum, claiming that it assumes that the curriculum can be valued only as it contributes to certain extrinsic goals, and only its 'utilitarian ends' justify the curricula means. He adds:

> 'The technically oriented evaluator tends to look but not to see, to hypothesize but not to realize, to find facts but not to make meanings, to participate but not to create, and to evaluate but not to value.' (p. 332)

We take the Palestinian school as a unit of analysis. The integration of both the content knowledge presented in the curriculum and the pedagogical knowledge can help us learn more about how the new Palestinian curriculum works. This means that we have to look at the basic foundations and the general objectives of the new curricula, the textbooks, teachers and students and administrators' practices, and the power relations among them. And this also means studying the process of policy making and the type of communication within the educational organization i.e. the MOE. The model of pedagogic practice outlined by Bernstein (1990) and elaborated by Morais, Davis, Neves, and Danial (Morais et al, 2001) can form a basis for conceptualizing types of pedagogical practices and the type of pedagogical knowledge transmitted through these practices. The competence versus the performance model provided by Bernstain (1996) and applied to different pedagogical practices, i.e. discourse, time and space, evaluation, control,

autonomy and others, show how a society can help in understanding the pedagogical knowledge transmitted throughout the Palestinian educational system.

The QCERD Centre realizes, however, that schools are not 'isolated entities,' that they have to be examined in their socio-economic and political contexts. According to Apple (1979; 1995), schools have three functions: 'accumulation,' through which students are hierarchically ordered, grouped, and taught different norms, skills and values in order to be prepared for the needs of the job market; 'legitimation,' by which social control is practiced and dominant ideologies, values and norms are filtered and conditions for their acceptance are created; and 'production,' the process by which students are prepared to enter universities where they eventually work in the production of knowledge. In order to have a clear vision of how curricula operate, and to understand the functions of the school, it is necessary to make connections between the curricula and the culture of the society in which it is produced.

In the future, other areas of schooling will need to be scrutinized when adopting the socio-cultural perspective of curriculum evaluation. The QCERD will need to look not only at the overt curriculum represented by various materials and texts that are filtered through teachers, but also at the 'hidden curriculum' that is embedded in the daily interactions and regularities of school life. According to McCutcheon, the hidden curriculum 'is not intended and is transmitted through the everyday, normal goings-on in schools' (1988: 191). But for others, the hidden curriculum is intended in that the way knowledge is selected, organized and assessed in schools is 'taken-for-granted' to be legitimate knowledge and to reflect the interests of powerful groups in society (Young, 1971; Keddie, 1971; Bourdieu & Passeron, 1977; Apple, 1995). Acknowledging this, Willis (1977) and Giroux (1983) show how students might, in fact, resist the official knowledge imposed by powerful groups through the functions of schools, by criticizing the functionalist perspective of the hidden curriculum that considers students as passive receivers of social norms. Apple & Beyer (1988) complement Willis (1988) and Giroux (1983), claiming that students have the ability to reinterpret dominant ideologies in the overt and the hidden curricula, pointing out that:

> 'we cannot take for granted that students are passive receptacles into which the school 'pours' ideological content and values; nor should we assume that students do not have some creative responses to the sorting and selecting functions of the school.' (p. 343)

For example, following Merton (1957), Peter Woods (1980) studied students' reactions to school goals and methods of attaining these goals and found that these

reactions ranged from acceptance to rejection. Woods adds that many students reject the 'rules, rituals, and regulations' and may 'disrupt lessons and even physically assault staff or destroy properties' (pp.14-18). Woods also mentioned that there are students who reject the school norms but they substitute others. This group, 'the rebellions,' as Woods calls them, is less threatening than the first group that he calls 'the intransigence'.

In the following section, I will present results of an ongoing research project carried out by the QCERD concerning the new science curriculum, which has adopted the socio-cultural perspective and takes the Palestinian school as a unit of analysis. Among the findings is the fact that Palestinian classrooms are not based on democratic practices and instead transmit models of knowledge based on authoritarianism.

## Knowledge and values in the new Palestinian science curriculum

### *Methodology*

Taking the socio-cultural perspective of curriculum evaluation as a base, and the school as a unit of analysis, the QCERD worked with its Action Research Unit (ARU) with teachers at pre-service and in-service levels to evaluate the new science curriculum through action research projects. The ARU held focus group sessions with school principals, teachers, parents, students and supervisors who are the main key persons responsible for training and monitoring the educational process. In addition, the unit analyzed the new science textbooks and studied the text, signs, pictures, and relations among them. The unit examined the issue of educational consistency in the science curriculum and how the goals of the science curriculum and the general basic principles are interpreted and incorporated by the textbook writers. Most importantly, the unit studied how competencies and values such as cognitive competencies (process of scientific thinking, higher order and critical thinking, reflection, etc.); socio-affective competencies (participation, cooperation, and responsibility) personal-social values (personal realization, self-confidence, justice, truth, and persistence and right to difference), and social values (democracy, citizenship, multiculturalism, etc.) are presented in the curriculum and are mediated by teachers.

Classroom observation, teacher diaries and teacher conversations were considered major tools for data collection concerning pedagogical practices. Within action research projects, the ARU worked with a group of science teachers on specific science units selected from the textbooks. The teachers with the center's researchers reformed the chosen unit to coincide with new approaches in

teaching like 'integrated teaching and learning', 'science technology and society approach', 'authentic assessment approach', etc. Then the teachers applied the reform unit in their classrooms, video taping their classes, writing diaries, and returning to meet with the group to discuss the implementation of the unit.


## Findings and discussion

Analysis of the data, collected from science textbooks, classroom observations, and interviews shows a number of results which can be grouped under two categories: first, the content knowledge transmitted from science curriculum objectives and from the goals, content, activities, and evaluation in the textbooks, and secondly, the pedagogical knowledge transmitted from pedagogical practice.


### *Content knowledge*

The Palestinian science curriculum is embodied in science textbooks which have been approved by the MOE and given to school teachers as 'ready to teach'. They are taught by subjects, each given a particular number of units. These subjects are: Humans, Plants, Animals, and Microorganisms, Matter and Energy, Environment, the Earth and the Universe, the Atmosphere and Meteorology, Communications, Science, Technology and Society. The general objectives of the new science curriculum (MOE, 1998) include the transfer of scientific knowledge to students and the promotion of scientific thinking, problem solving, innovative and critical thinking, inquiry and investigation and individual initiative. Content analysis reveals that the new science textbooks fail to emphasize those cognitive competencies that are fundamentally expressed in terms of investigative process (e.g. hypothesis formulation, planning experiments, results interpretation), or the competencies for developing them (scientific rigour, learning to think, organizing information).

The science curriculum emphasizes the need to understand the general principles, concepts, and theories that explain the world around us. In general, the texts appear to transfer a significant body of scientific knowledge to students. However, they tend to focus more on results than on the process of scientific discovery and investigation. In essence, the texts present a body of knowledge that students are expected to learn, understand and recall.

Analysis of the activities in the new science textbooks reveals that most of them represent lower order thinking activities. Students are offered the results of scientific exploration. They are not encouraged to experiment; they are only

instructed to distinguish between what is true or false. Students also are asked to measure, draw and calculate without knowing why they are doing so.

Scientific concepts and theories are presented using difficult and complex language. Therefore, students are likely to end up memorizing key concepts without fully understanding them. The result is that students will often rely on intuition rather than scientific concepts and may end up holding misconceptions about science. The texts fail to establish a link between observation and conclusion, thereby leaving students unable to understand the purpose of the scientific experiment or its inner logic.

An examination of the evaluation process reveals the following: most of the questions focus on results-whether students understand general principles, whether they can apply them and eventually recall them. Few questions call for analysis and evaluation and fewer still encourage students to engage in higher order thinking. To a large measure, the texts are test-driven. The texts seem to suggest that there is a scientific method that one can use by following specific steps and procedures. This process does not encourage scientific thinking because the texts move back and forth between various kinds of questions, answers to those questions, and experiments that test those answers.

With reference to scientific literacy, the QCERD evaluated one unit (the human body) in the science textbook (grade 7) according to criteria outlined in Chiappetta, Sethna and Fillman (1991). The purpose was to study what content is emphasized relative to the various themes of scientific literacy, such as:

1. The knowledge of science[4]: facts, concepts, principles and laws, hypotheses, theories and models; and asking students to recall knowledge information.
2. The investigative nature of science: whether materials require students to answer a question through the use of materials or through the use of charts, tables, to make a calculation, to reason out an answer or engage students in a thought experiment or activity.
3. Science as a way of thinking: whether materials describe how a scientist experiments, show the historical development of an idea, emphasize the empirical nature and objectivity of science, illustrate the use of assumptions, show how science proceeds by inductive and deductive reasoning, gives cause and effect relationships, discusses evidence and proofs and highlights the fact that science is a discipline that is disposed to self-examination.
4. The interaction of science, technology and society (STS): whether materials describe the usefulness of science and technology to society; stress the negative effects of science and technology on society; discuss social and ethical issues related to science and technology; illustrate possible careers in scientific and technological fields.

We obtained the following results (Moughrabi et al., 2002):

a) Analysis of scientific literacy themes in the narrative text reveals the following percentage distribution: the knowledge of science (73%), the investigative nature of science (12%), science as a way of thinking (5%), and the interaction of science, technology and society (10%).

b) Analysis of the specific objectives of the unit reveals the following points of emphasis: knowledge of science (71%), the investigative nature of science (12%), science as a way of thinking (8%), and the interaction of science, technology and society (12%).

c) Analysis of the questions reveals the following points of emphasis: scientific knowledge (73%), the investigative nature of science (5%), science as a way of thinking (19%), and the interaction of science, technology and society (2%).

d) Analysis of the figures and illustrations reveals the following points of emphasis: scientific knowledge (76%), the investigative nature of science (12%), science as a way of thinking (5%), and the interaction of science, technology and society (5%).

The content analysis reveals that the science curriculum tends to emphasize the transfer of a body of scientific knowledge to students and ignores the investigative nature of science, thinking competences and the interaction of science, technology and society that are essential for the promotion of scientific literacy and values of democratic practices. These results coincide with what Brown (2001) says about the Palestinian science textbooks that they are still 'based on the idea that they impart knowledge from a position of authority and their encouragement of critical, creative, and independent thought is limited' (p. 24).

*Pedagogical knowledge*

Despite the attempts to build more interactive pedagogy, science textbooks fail to provide students with a constructivist approach in accord with the nature of science, as it claims to do in the general objectives. Instead, it introduces scientific knowledge as a set of fixed and discovered truths to be taught by the teacher. As a result, the teacher is placed at the center of the educational process while the students are considered to be passive receptors rather than active disseminators of knowledge.

Furthermore, the new science curriculum fails to foster personal and socio-affective competencies. Classroom observations reveal that science teachers, especially those who are new to the profession, tend to use the space allowed (through pedagogic practice) less than is desirable and mostly adhere to the

instructions given in the curriculum's specific guidelines (sometimes given by their supervisors) for discipline matters. Factors like teachers' ideologies, school culture, classroom settings and peer influence play an important role in the way teachers mediate the messages contained in the science curriculum and the way they direct their practices. In many cases, teachers tend to recontextualise the general goals in the science curriculum in a way that undervalues socio-affective competences. For example, because of dense subject matter, overcrowded classrooms, and the test driven nature of the curriculum, science teachers try to cover the material and do not have much time to engage students in discussion and cooperative work. As a result of this undervaluing, not only the principles of the curriculum are lost but also, more importantly, there is a tendency to reduce learning to its instructional aspects and to focus on its lower cognitive and socio-affective developments. Al-Ramhi and Davis (2002) indicate that despite the training programs given by the MOE concerning teaching practices, lecturing was still the dominant pedagogy, where 'emphasis was still laid on attaining the status of knowledge, rather than the process of acquiring knowledge' (p. 69).

The low quality of higher education programs which separate theory from practice in actual settings, leads Palestinian science teachers to rely on their colleagues and in many cases on their previous knowledge about teaching acquired from their own school teachers when they were students. Hargreaves (1995) writes that many teachers give up their 'ideal theory world' obtained at university because of the power relations between colleagues, students and administrators, in order to coexist with the school culture. This highlights again the need for cooperation between the MOE and MOHE.

The suggestions of Palestinian educators for curriculum reform are practically absent in the new curriculum produced by the Ministry of Education. Instead of the first curriculum team plan for educational reform and innovative curriculum based on democratic decision-making and on critical thinking, one finds a notion of curriculum that transmits authoritarian knowledge and values. The cognitive and social competencies that are necessary for developing a critically thinking person and self-learner are limited in the new science curriculum.

Studies on education for democracy focus on the notion that cognitive, personal and socio-affective competencies such as critical thinking, participation, cooperation, responsibility, personal realization, self-confidence, justice, truth, and persistence are all principles necessary for developing a democratic society (Dewey, 1916; Wood; 1990; Smyth, 1997 and others). However, social evaluation of the new Palestinian science curriculum shows that attempts to filter notions of democracy to the school level often fail to bring about any significant levels of change.

For many, the new Palestinian curriculum is a site of tension between progressives and conservatives, and for others the resulting textbooks are an uneasy compromise 'with something for every one' (Brown, 2001). Such compromise can be seen in the science curriculum concerning, for example, the role of gender. Men can be seen in some illustrations doing housework and working in the kitchen. Illustrations also show veiled women coexist with those unveiled. The science curriculum is also a topic of debate between secular and religious parties in the Palestinian society, as it is in many other countries. Koranic verses are cited at the beginning of various units and concern the subjects being studied in this unit. Conservatives justify citing Koranic verses in science textbooks in order to show how science is compatible with Islamic religion and a way to integrate science with other subjects. Progressivists with secular views, on the other hand, say that this citing supports the traditional point of view about scientific knowledge as a fixed truth and prohibits students in the science classroom from practicing the skills of doubt which is one of the most important aspects of science. Even though, there are no studies been conducted on how inserting Koranic citing affect students' thinking skills, it is safe to say that teachers' ideology plays an important role in forming the kind of knowledge imparted to students through her/his pedagogical practices.

In general, the new Palestinian curriculum leans toward authoritarian pedagogy. Despite introducing new subjects such as Civic Education and National Education, in the Palestinian curricula, which include material on human rights and democracy, there is no clear pedagogy that incorporates the values and attitudes of democracy. Values that permeate the new textbooks focus on order, discipline, cleanliness and personal hygiene, respect for parents, teachers and others in authority, respect for elders, and other social and religious values (Moughrabi, 2002). Moughrabi adds that there is emphasis placed on the need for affiliation such as social harmony, getting along with others, but on the other hand there is no practical attempt to introduce 'achievement' as a necessary theme for economic development and growth. Relating to the science curriculum, the traditional approach of compartmentalizing science from other social sciences still persists; there is no such pedagogy of incorporating values and attitudes of democracy among science subjects.

For teachers, the MOE school system is highly centralized and bureaucratic and the supervisory system for them is still, in many of its aspects, authoritarian. Many educators point to the common characteristics between the existing Palestinian educational system and that in other Arab regimes (Hashweh, 1999). Hashweh says, 'Palestinian schools still concentrate on rote learning and memorizing, instead of developing self-learning, critical thinking and problem-

solving skills that help in personal and social decision making' (1999: 24). The Arab educational systems, according to Bahlole (1997) and Sharabi (1975), share common features that concentrate on rote learning, punishment, and ignore the role of the mind. These educators consider values such as affiliation, respect of authority figures, and dependency obstacles to democracy which reinforce authority in society. Moughrabi goes further, claiming that the Palestinian Authority, since it assumed control in 1994, has 'imposed patterns of governance quite similar to those that exist in various Arab countries' and 'replicates the very same structure and procedures that exist in those countries especially in the field of education' (2002: p11, 12).

There is much evidence to suggest that Palestinian schools which use the newly implemented Palestinian curriculum play an important role in accumulating, legitimizing, and producing the knowledge and values of control and authority. This role is emphasized by the deteriorating conditions of the Palestinian higher education system, which has made no contribution to curriculum policy. The 'consumer-producer' relationship model of teachers and students between the MOE and the MOHE (Sanyal, 1999), would not necessarily work without the consumer-producer model of knowledge, i.e. the process of transforming the role of teachers from consumer and transmitter of knowledge to an active producer of knowledge. This model reveals the manner by which power, control, and authority function through the curriculum and how they shape the organization of Palestinian society itself.

Internal critics of the Palestinian educational system and the new curriculum are now questioning the kinds of knowledge and values this curriculum offers to Palestinian students. Today, what is ultimately needed is a new interactive pedagogy that can penetrate the educational system and can emancipate rather than domesticate the individual, and what matters for the future is how rather than what subject matter is taught. The 'banking' model of knowledge and teaching can no longer be justified in the educational system (Freire, 1970), and the key element for change must be the Palestinian teacher.

## Teacher 'empowerment' through a new educational vision

Teachers' empowerment lies in the explicit recognition of the teacher as the key to professional and curricular development. Educators need to know how teachers learn, what types of knowledge and levels of knowledge acquisition are necessary to become effective teachers, and what contexts are most conducive to learning how to teach. This cannot be done without cooperation between the MOE and the MOHE.

The model of curriculum innovation presented by Lang and others (Lang et al., 1999) which takes either an imposed path from the government, or a self-organized path within school practices, links curriculum innovation and teachers' professional development. In the case of the imposed curriculum, failure can be related not to teachers lack of professionalism, but to 'insufficient consideration of teacher qualifications, the existence of different goals for pre- and in-service teacher training, contradictory demands of different stake holders and controversial intended outcomes of reform' (p 123). The obstacles faced the implementation of Machar 98 (Tomorrow 98) project initiated by the Israeli Ministry of Education, Sports and Culture is one example among others given by the authors to illustrate how curriculum innovation and teacher professional development are linked. According to the authors, this imposed reform and its new 'science and technology' curriculum, that aimed to integrate technology into science (biology, chemistry and physics), faced obstacles to a successful implementation mainly because of the lack of coordination between the Ministry (the party that was responsible for the in-service teachers), and the Israeli universities, where little was done to change pre-service teacher education.

Educational reform is needed in order to raise the quality of education in Palestine. The reform should be based on the 'micro level' i.e. on the school level where schools can be sites for reflection and constructive self-criticism. (Land et al, 1999). The Palestinian MOE, on the other hand, insists on 'reform on a macro-level' where outer control of input and output of the educational system is practiced. According to Terhart (1999) this kind of control is not concerned with indicators of quality, but with 'accountability' concerns based on students' performance.

The QCERD (2001) has developed a new vision for the educational system in Palestine, which relies on a 'partnership' model between the MOE and the MOHE, where schools are settings and classrooms are libraries and in-service and pre-service teachers, university teachers, and administrators work collaboratively in a real authentic learning social context (Vygotsky, 1978; Cochran, DeRuiter, & King, 1993; Bullough & Gitlin, 1991). Within this social context, situated knowledge is constructed and transformed to other settings (Brown, Collins, & Duguid, 1989). Gordon Wells (1999) suggests that situated activities within a social context are a site of potential change and renewal since every situation is different and unique, thereby challenging the participants to construct new solutions. Following Vygotsky, Wells discusses how collaborative group work, dialogue, and inquiry-oriented practices are essential components of his proposed model about schools and classrooms as 'communities of inquiry'. According to this model, inquiry is placed at the heart of the curriculum and the teacher's role

is seen as co-inquirer with the students engaged in critical thinking and democratic decision making processes.

Following from this, the QCERD, through its ARU has begun to implement the 'partnership' model. Pre-service science teachers from different Palestinian universities and colleges, together with in-service science teachers coming from the MOE's schools, work with the ARU's researchers in collaborative action research. According to Elliot (1991), collaborative action research supports the transformation of teachers' and facilitators' consciousness through reflection on their current practices, suggesting alternative actions, and providing a context of implementation and evaluation of these actions. Action research facilitates the teacher's empowerment process by reconceptualizing her/his role as producer rather than user of knowledge. The participants in action research work on projects with different topics of investigation through which purposeful situated and authentic activities are incorporated, and the new science curricula are evaluated. Through the action research projects undertaken by QCERD, pre-service and in-service science teachers learn to become researchers and reflective practitioners in their schools (Schön, 1983). For example, pre-service teachers at the Educational Sciences College in Ramallah, worked with in-service teachers in UNRWA schools under a collaborative action research project run by the QCERD action research unit (Al-Qura'n, 2001). The participants worked on science curriculum development and evaluation by applying the 'curriculum inquiry cycle' model (Northwest Regional Educational Laboratory, 1998) and found that the project improved teaching and learning processes, provided teachers with new knowledge and skills to examine science concepts, and to relate science activities to everyday life and to the Palestinian context. Furthermore, teachers acquired new skills and learned how to implement new methods in which teaching processes become student-centered.

Another example of collaborative action research held at the QCERD was the Science, Technology and Science project (STS) (Khaldi & Wahbeh, 2000), through which the pre-service and the in-service teachers, together with the researchers, worked on developing a science unit on water from the STS perspective, and included social problems caused by the misuse of water resources. As a result of joint reflection between the participants, the project enriched teachers' insight into the problems of their teaching style, and facilitated an important change in their beliefs and practices concerning student-learning abilities.

Thus, in the QCERD action research projects, schools and classrooms are considered to be places of inquiry where knowledge is created and recreated between the participants, and teachers are empowered by their participation in curriculum development and evaluation processes.

## Conclusion

I have attempted to evaluate the new Palestinian Science curriculum from a socio-cultural perspective, beginning with a review of the historical and the current situation of Science Education in Palestine. By taking the school as a unit of analysis and considering the 'school culture' and the social power relations outside, I tried to show how Palestinian schools are operating as agents of accumulation, legitimization, and producers of knowledge and values of control and authority.

The MOE has failed to integrate the notions of democracy that were called for in the First Palestinian Curriculum Plan and by many Palestinian educators. The new Palestinian science curricula (Grades 1, 2, 6, and 7) represent official texts produced by the MOE and transmit aspects of authority which many have described as replicas of the educational systems in most Arab countries.

The notions of the 'democratic classroom' and the 'community of inquiry' can only be achieved through a real partnership between Palestinian universities and schools, where teachers and researchers work collaboratively to critically evaluate the role of schooling in Palestine. Moore & Young, following Collins (1998) and Alexander (1995) argue, 'it is the social nature of knowledge that in part provides the grounds for its objectivity and its claims to truth' (2001: 450). This argument is the foundation of what has been recently called the 'social realist theory of knowledge,' which has as its first goal to reveal the way in which external power relations and control affect knowledge, both in research and curricula.

The partnership model proposed earlier, challenges the MOE and the MOHE to move towards connectivity between disciplines and integrated subjects rather than isolated entities knowledge, and towards general skill knowledge rather than a curriculum based on subject matter.

Finally, science education in Palestine lacks an interactive pedagogy for incorporating the notion of democracy. The need for democracy cannot simply be translated through peppering textbooks with words and principles of democracy. I agree with Carr (1998: 337) who points out the relationship between democracy and curriculum by saying:

> ''Democracy' and 'curriculum' stand in a reciprocal relationship
> such that each provides the foundation on which the other is
> erected. To recognize this is to acknowledge that without a
> democratic transformation of society a 'curriculum for democracy'
> will remain ineffective' and that without the educational and
> political struggle to promote a 'curriculum for democracy' the
> further democratization of society is unlikely to occur. The
> democratic transformation of both the curriculum and society is
> thus the condition for the democratic development of each.'

## Notes

1. These areas are now being reoccupied by the Israelis
2. UNRWA schools serve refugee students from kindergarten to grade 9. These students must enroll in governmental schools for secondary education. While students at UNRWA schools follow the National curriculum used in governmental schools, students at private schools follow other foreign syllabi besides the National curriculum.
3. The new Palestinian science textbooks are based on the general philosophy of the Palestinian curricula and on the new science curriculum outline.
4. We must be aware that cognitive level objectives are easier to write, more specific and cover a lot of content. That is why we expect a higher percentage of this type of objectives but the percentage can give us an idea of how much the science curriculum is biased towards these objectives.

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# SCIENCE EDUCATION IN THE SERVICE OF BRIDGING THE ISRAELI-PALESTINIAN DISPUTE OVER WATER RESOURCES

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**Abstract** – *In 1994 an educational program aimed at changing prevailing attitudes to favor peace and coexistence in the region was launched in the Israeli educational system. The program focused on the crucial conflict over water resources between Israel and its neighboring Arab countries – an issue at the heart of the Israeli-Arab conflict. The rationale of the educational program was based on cognitive approaches to attitudinal change and conflict termination, assumption being that providing relevant, 'major' information (Shamir and Shamir, 1996) would prompt the restructuring of existing salient beliefs regarding peace and cooperation and later the formation of attitudes in favor of them. A comprehensive curriculum focusing on water management issues was constructed and implemented in teachers colleges and schools. Findings from an evaluation study that followed the implementation of the curriculum showed large knowledge gains but only minor attitudinal changes, disappointing findings that led to the consideration of an alternative model to attitudinal change, incorporating a value component. In the new model, which evolved from Fishbein and Ajzen's (1975) theory of 'reasoned action', values function as mediating components between beliefs and attitudes. Learning activities aimed at decision-making in relevant dilemmatic situations enabled the learners to become aware of the values that govern their decision-making and allowed them to critically assess their views and attitudes. In light of these findings some thoughts on the future of this evolving project conclude the paper.*

## Introduction

*I*n 1993, after the signing of the Oslo Agreement and in the wake of the peace treaty with Jordan, it became clear to policy makers in Israel that moving from war to peace cannot be achieved by political actions alone but also requires public legitimization of the consequences of peace. At that time a monthly public opinion survey called the Peace Index Survey (Yochtman-Yaar, Harman and Nadler, 1996) revealed only moderate (50%-60%) percentages of people supporting the different

peace plans that were initiated. Many agents, amongst them the educational system, were recruited to bridge the discrepancy between policy decisions toward peace and public readiness for it. Amnon Rubinstein, the then Minister of Education, wrote:

> 'We should present the goal of attaining peace with our neighbors as a national aim and explain its vital importance, its contribution to the security and prosperity of Israel. However, we should also present the variety of opinions and the legitimate debate concerning the political agreement needed.'
>
> (Special Circular No. 14, May 1994, pp. 7, 8)

The following year, 1994, was officially announced as the 'Year of Peace', dedicated to curricular activities related explicitly to the Palestinian-Israeli conflict and to the peace process in all schools.

As part of this general orientation of the Israeli educational system to prepare youngsters to live in an era of peace, and in response to the minister's call, a small-scale educational program aiming to change prevailing beliefs and attitudes among Israeli youngsters to favor peace and coexistence in the region was initiated at the department of science at the Kibbutzim College of Education, Tel Aviv.

The conflict over water resources between Israel and its neighboring Arab countries was chosen to represent the Arab-Israeli conflict. A curriculum, centered on this issue, with scientific, technological, societal and political content in line with an STS – Science Technology and Society approach (Fensham, 1992) was developed and taught to student teachers in the science department at the college. Later the student teachers carried out this same program in junior high schools as part of their student teaching duties. This small project grew into a larger collaborative project between Israeli and Palestinian researchers and educators who shared the hope of ending the dispute between Jews and Arabs living in the region. The collaborative project undertaken in 1995, was supported by the Netherlands-Israeli Research Program (NIRP). A joint educational program was planned and executed in an experimental sample of junior high schools in the Palestinian Authority and in several teachers colleges and junior high schools in Israel. In Israel this curriculum gained the recognition of the Ministry of Education and was published. Since 1999 it has become one of the official peace curricula taught tin junior high school.

The joint educational program was guided by cognitive approaches to attitudinal change and conflict termination. Early on in the program it was found that although the participants held strong beliefs regarding the water dispute, these were not backed by evidence. It was assumed that providing relevant information

of a 'major' nature (Shamir and Shamir, 1996) on the issues would lead to the restructuring of existing salient beliefs regarding peace and cooperation and, later on, the formation of attitudes in favor of these.

This paper is dedicated to describing the Israeli curriculum 'Water in an Era of Peace', which constitutes the core of the educational program on the Israeli side. The paper will present the cognitive approach to attitudinal change and to conflict termination that form the base of this curriculum and the limitations of such an approach. Since an evaluation study that followed the implementation of the curriculum showed only minor attitudinal change in the desired direction, a new curriculum based on a more comprehensive approach to attitudinal change was developed and trialed. We will describe how this alternative approach evolved and illustrate the nature of the two types of curricula that stemmed from each of the approaches.

We will start with a short introduction on the nature of conflict relating it to the conflict over water resources in the Middle East – the main issue in our peace curricula. This introduction is then used to justify the cognitive approach applied in our first curriculum. A typical learning activity will demonstrate this. Findings from the evaluation study carried out while implementing the curriculum, and conclusions drawn from them, are used in elaborating on the extended new approach. Here too, a typical learning activity that illustrates the second curriculum is presented. In light of some experimental results from trying the second curriculum, some thoughts on the future of our evolving project will conclude this paper.

## Conflict emergence, development and termination

An important distinction between *realistic* versus *unrealistic* conflict (Coser, 1956) directed us to a cognitive approach to peace education. *Realistic conflicts* stem from opposed interests between two parties which may have negative relationships of two types: dominance or competitiveness over rare resources such as land, water, etc. (Campbell, 1965; Levine and Campbell, 1972). *Unrealistic conflicts* are mainly regarded as a psychological response to frustration and fear. In such cases, there is a *perceived* conflict of interest that is not necessarily realistic. Generally, realistic and unrealistic conflicts occur intertwined to varying degrees. Levine and Campbell (1972) describe the web of psychological responses that may escalate a realistic conflict into an unrealistic one as follows:

> 'At the basis of realistic conflict, there is a real conflict of interest that causes real threat. Real threat causes hostility to the source of threat as well as solidarity within the ingroup. This solidarity

leads to own ingroup identity and ultimately an increase in
ethnocentrism. Increased ethnocentrism can lead to escalation of
the conflict.' (pp. 29-42)

Orr (1995), referring to a comprehensive model of conflict (Fischer, 1990),
offers a full description of the emergence, evolvement and resolution of intergroup
conflict which also demonstrates the intertwining of realistic and non-realistic
elements:

1. Intergroup conflicts usually begin with a real conflict of concrete interests; a
   negative dependency of aims exists, i.e., attainment of one side's aims is
   negatively correlated with the attainment of the other side's aims and
   competitive orientation and interaction emerge (zero-sum thinking).
2. In real conflict, cultural differences and a history of conflicts create a
   perceived threat.
3. Perceived threat causes ethnocentrism which further causes ingroup solidarity
   on the one hand and intergroup hostility on the other.
4. Ethnocentrism decreases the level of trust between the parties involved.
5. Where communication is inefficient, interaction is competitive; feelings of
   threat, mistrust and ethnocentrism intensify the conflict.

When talking in terms not of socio-psychological processes, but, rather, of
epistemic structures (Bar-Tal, Kruglanski and Klar, 1989) conflicts can be
regarded as cognitive schemes, mental representations of knowledge, the content
of which refers to the incompatibility of goals between parties. In line with this
notion of conflict, Bar-Tal and his colleagues (1989) talk about *conflict resolution*
which requires epistemic restructuring or the replacing of a conflict scheme with
an alternative one, for instance, compromise. In all frameworks described, conflict
is always characterized by realistic incompatible interests of the two parties
involved. It is beyond the scope of any educational intervention to deal with these.
All that is left for educators to do is to deal with the unrealistic elements of the
conflict – fear, mistrust, ethnocentrism and above all, the perceived beliefs of
incompatibility of aims and the zero-sum way of thinking. It should be noted that
although the discourse on conflict within the epistemic and the socio-
psychological framework is different, the essence of termination of the two types
of conflict remains the same. According to both approaches, conflict termination
seems to be dependent on processing new information, forming new beliefs and
attitudes or changing existing conflict schemata. Thus, in the following section we
will deal with definitions of beliefs and attitudes and with mechanisms of forming
and changing them.

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## Definitions of attitudes and beliefs and mechanisms of formation and change

Attitudes have long been an object of research, yet there is no accepted definition (Olsen and Zenna, 1993). Several elements tend to reappear in the various extant definitions. First, there is the evaluative nature of attitudes – a psychological tendency to evaluate an object with some degree of favor or disfavor (Eagley and Chaiken, 1992; Zanna and Rempel, 1988). Second is the knowledge structures which support the evaluate stance a person holds (Fazio, 1990; Kruglanski, 1989; Pratkanis and Greenwald, 1989). Some definitions center on the affective dimension: Bem (1970) argued that 'attitudes are our likes and dislikes' (p. 14), while Greenwald (1989) defined attitudes as 'the affect associated with a mental object' (p. 432). Lastly, in some cases, attitudes are regarded as a pre-disposition to act, e.g, mental state of a person who has a favorable or unfavorable intention to act toward an object, person or idea (Triandis, 1991), or as learned dispositions to consistently respond favorably or unfavorably toward an object (Ajzen and Fishbein, 1977, 1980; Fishbein and Ajzen, 1975). In that line of thinking, McNaughton (1998) regards attitudes as the motivational push that drives an agent to act.

Fishbein and Ajzen (1975) made an important distinction between attitudes and beliefs and in doing so succeeded in uniting the different elements that appear in the definitions of attitudes. According to them, whereas attitudes refer to a person's favorable or unfavorable feelings (affect) toward an object, beliefs link this object to specific attributes (knowledge) of the object. The more probable the association between the object and its attribute, the stronger the belief. This probability is, of course, experienced subjectively.

Beliefs may be formed as a result of direct observation, through self-generated inferences, or it may be indirectly formed by accepting information from such outside sources as friends, media, etc. (Ajzen, 1988, p. 33). Beliefs can be descriptive ('I believe the attitude of the object to be true or false'), evaluative ('I believe the attributes of the object to be good or bad') or prescriptive ('I believe the attributes of the object to be desirable') (Rokeach, 1968, p. 124).

Attitudes are a set of beliefs interrelated around a common object or situation, concrete or abstract. In terms of the theory of Reasoned Action (Ajzen and Fishbein, 1977), attitudes follow reasonably from beliefs people hold about the object of the attitudes, just as intentions and actions follow reasonably from attitudes. Although a person may hold a large number of beliefs it appears that only a relatively small number of them play a role in attitude formation – these are called *salient beliefs*. The totality of salient beliefs multiplied by the strength of these beliefs serves as the informational base that ultimately determines our

attitudes and behaviors. Rokeach (1968) distinguished also between *core beliefs* and *peripheral beliefs*. Core beliefs are more important and therefore more resistant to change. Peripheral beliefs, those that are less important to the individual, are connected with the core beliefs forming a beliefs' structure. McGuire (1985) suggested when they form attitudes and make decisions people often consider just one salient attribute of an attitude object, presumably the most important attribute.

An input of relevant information, whether based on personal experience or on outside sources (such as media, books, or other persons), and structuring the ways in which this information is processed, is regarded as the basis for forming or altering beliefs and, ultimately, attitudes.

Two mechanisms of information processing: persuasion and epistemic restructuring, were used as part of an educational program. Persuasion is defined as a 'conscious attempt to bring about a jointly developed mental state common to both source and receiver, through the use of symbolic cues' (Koballa, 1992). Persuasion is considered successful when a belief or an attitude change is grounded on considerations perceived as convincing by the recipient.

Two leading groups of researchers on persuasion processes are Petty and Cacioppo (1981, 1986), with their *elaboration likelihood model,* and Chaiken (1987) and Chaiken, Lieberman and Eagley (1989), with their *heuristic-systemic model*. In both models, individuals are assumed to process a persuasive message carefully when they are motivated and able to do so. When the arguments in the message processed are strong and the information is relevant, persuasion occurs and consequently beliefs and attitudes are formed or altered.

The other mechanism of information processing view attitudinal change through an alternative theory, the *lay epistemic theory* (Kruglanski, 1980a,b; 1989). Here, the process of belief/attitude formation is described as a process of restructuring existing cognitive schemes (beliefs or attitudes). This process contains two phases: the *generation phase*, when information is stored in knowledge structures, and the *validation phase*, when the individual tests the generated cognitive structures or their implications against the evidence s/he possesses. The more consistent the two, the more confident the individual will be in holding a belief. In both mechanisms of attitudinal change described above the processing of information plays an important role and humans are viewed as rational, knowledgeable organisms who use information to form and evaluate their beliefs, make judgments, decisions, and build their attitudes. This view led us to decide upon the nature of the educational intervention needed for our purpose.

*TABLE 1: An Exemplary Activity: Water in an Era of Peace*

## Conflict Related to International Water Resources

Students are invited to study the problematic aspect of using shared water resources, the international treaties and principles employed in settling disputes over international water sources, their benefits and shortcomings.

### First Activity

- Read definitions of international water resources and determine which of the water resources in Israel (surface and ground water) fit these definitions.
- Study international laws and principles concerning rights and allocation of international water sources: the Helsinki Treaty (1966); the 21st Century Agenda (1992), and the Bahrain Agreement (1993).

In light of these documents, study the peace treaty between Israel and the Hashemite Kingdom (1995), especially those sections related to water agreements, and compare the international principles on rights and allocation of water to the relevant items in the Israeli-Jordanian document.

### Second Activity

A case study: Applying international law to the problematic issues concerning the Yarmuk river – a river that crosses Syria, Jordan and Israel.

- Studying the geographical and hydrological characteristics of the Yarmuk river.
- Reading a set of abstracts from Israeli newspapers related to the issue of managing the Yarmuk river water. Establish your own opinion on the issue.

### Third Activity

A Simulation Game

Groups of nine participants, each representing one Middle East country, and additional UN representatives are chosen to negotiate water treaties. Each of the participants has to represent the interest of his/her Middle East country – using the material studied during the project and additional sources – each group appears at the negotiating table with their own flag, costume and other symbols of national identity.

The game aims to achieve as many as possible water arrangements among the countries – both bilateral and multilateral. Each agreed upon arrangement scores a point. Success depends on knowing the facts about the country represented (economic, political, natural resources, population, etc.), the ability to convince and persuade in a polite manner, rhetorical skills and listening skills.

## The rationale and characteristics of the educational intervention

In light of the above described 'information processing' models, a science curriculum that represented an integrated approach in science education was developed by the project team. Focusing on the water conflict in the Middle East, and especially on that part of it that had bearing on both Israelis and Palestinians, the curriculum offered information on the following topics: water as a global resource; water sources and systems in the region; groundwater, main aquifers, technologies for using groundwater, water uses and users; factors affecting availability and consumption of water; water balance of the countries in the region; technological, behavioral, economic, legal and political solutions to water scarcity.

In providing the above information, the curriculum tried to persuade (rather than to indoctrinate) that the solution to the water conflict between Israelis and Palestinians lies in cooperation and in compromises on both sides. An illustration of some activities from the Israeli curriculum will bear this out (see example on previous page).

## Results of the first educational intervention and the move from the 'information processing' model to the 'value laden' model

The implementation of the curriculum was followed by an evaluation study, which came mainly to assess the effect of the educational programs on participants' initial knowledge base and to estimate the impact of their knowledge change on attitudes. Findings from this evaluation study showed large knowledge gains but only minor attitudinal changes in the desired direction, examples of which would be: an increase in the willingness to act for the sake of peace and increased recognition that, without solving the water problem, there will be no peace; Increase in the groups' interest in joint management of water resources and weakening of separatist – territorial, views regarding water. (For further reading see Zuzovsky, 2000; Haddad, Zuzovsky and Yakir, 2000.) Unexpectedly, a significant negative association appeared between knowledge gains and attitudes in favor of peace, especially among Jewish student teachers. Since this was also the group with the highest knowledge gain score, it is clear that gain in knowledge alone does not necessarily lead to the formation of beliefs and attitudes in favor of peace.

In looking for explanations for these disappointing results it was assumed by us that the minor change in beliefs and attitudes is related to the nature of the information processed. It was found (Bar-Tal, 1991; Binyamini, 1994; Shamir

and Shamir, 1996) that when information is ambiguous, i.e., open to several interpretations, individuals do not necessarily encode all of it. Instead, they may assimilate only those parts that are congruent with their already existing beliefs and value systems. In their study on value preferences in the Israeli public opinion, Shamir and Shamir (1996) point to the central position of both the peace value and the security value held in the minds of the Israeli public. Positive attitudes toward peace are always accompanied by feelings of fear alongside feelings of hope, creating substantial ambivalence in regard to the peace process (Bar-Tal, 1991). When peace and security are closely intertwined in people's thoughts, they will be reluctant to go for peace. In the case of our educational program, information provided in the course of it, although relevant and direct, was complex and could be interpreted differently in light of already existing but conflicting deep beliefs: in favor of peace on the one hand and in favor of security on the other.

In another study carried out on civic and political attitudes of Israeli Jewish youngsters (Binyamini, 1994), high school pupils were found to be even more ambivalent toward peace than adults (Arian, 1994). High levels of reluctancy vis-à-vis peace were found among youngsters of low socio-economic groups and religious backgrounds. Even though these youngsters showed a general readiness for compromise and territorial concessions, on specific issues (like withdrawing from the Golan Heights [occupied Syrian territory] or compromising on water resources), they were less willing to compromise. Binyamini relates this finding to the security values and beliefs imprinted on the collective consciousness of Israeli society as a whole.

It has become clear to us that providing information solely does not guarantee attitudinal change. If we want to shape attitudes through cognitive mechanisms, the deep and enduring beliefs usually referred to as values should first be dealt with. This led us to develop our second model of attitudinal change, which already included an affective-evaluative factor.

## Values and the role they play in forming and changing attitudes and behavioral intentions

The definition of values is based on the definition of more basic terms, i.e., beliefs and attitudes which were previously discussed. A common feature of beliefs, attitudes and values is their hierarchical, organizational nature. This organization is hierarchical in terms of relevancy or importance. Thus some beliefs are more salient than others and some attitudes and values are more important than others. One way of representing this hierarchy is by using a

concentric representation with core beliefs, attitudes or values in the center of the relevant system. The more central the beliefs, attitudes and values, the more resistant to change they will be.

An attempt has been made to associate values with human needs: biological, social or societal (Schwarz, 1996; Schwarz and Bilski, 1987). Those adhering to this view assume that values function like needs to influence goal-directed behavior (Feather, 1995). In contrast to this view, Leibowitz (1985, 1968) claims that values are beyond human needs and indeed antithetical to them. He argues that in linking values to human needs, we erroneously assume that values have a causal foundation in physical or psychological reality. However, no-one *needs* to be honest, or brave, or committed to his homeland, etc. Values are measured not by what people gain from adhering to them, but rather by what they are ready to sacrifice for them.

Values are shaped and learned through experience. Once a value is internalized it becomes, consciously or unconsciously, a standard or criterion for: (i) developing and maintaining attitudes toward relevant objects and situations, (ii) justifying one's own and others' actions and attitudes, (iii) morally judging self and others, and (iv) comparing self with others.

> 'Once values are internalized, they become consciously or unconsciously a standard or criterion for guiding action and maintaining attitudes toward relevant objects and situations, for justifying one's own and others' actions and attitudes, for morally judging self and others and for comparing self with others.'
> (Rokeach, 1968, p. 160)

Given the role values play in shaping attitudes and behavior we integrated a value component within the theory of Reasoned Action (Fischbein and Ajzen, 1975). According to this theory, two kinds of salient beliefs intertwine in the formation of attitudes and norms that then affect the intention to perform a certain behavior: *personal* and *social beliefs*. *Personal beliefs* reflect the extent to which one believes that engaging in a certain behavior will lead to a favorable outcome. *Social beliefs* reflect normative beliefs about the worth of a specific behavior. These beliefs create attitudes and social pressure to perform, or not to perform, the behavior (subjective norm concerning the behavior). In the new 'value laden' model, values play a mediating role in these processes. They affect the conversion of *personal beliefs* into attitudes and the conversion of *social beliefs* into subjective norms. They are also involved in turning attitudes and subjective norms into intentions to act and then into action itself. Figure 1 represents the place of values in the model of Reasoned Action.

*FIGURE 1: Integration of values within the theory of reasoned action*
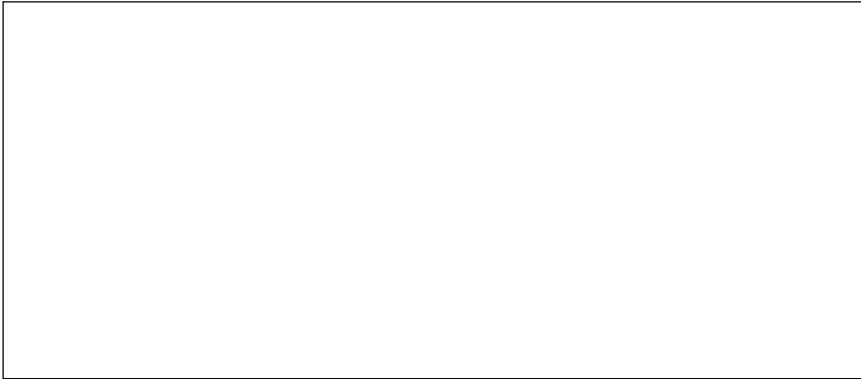
This new model grants the values individuals hold before starting the educational program special power in processing information provided during the educational intervention. In designing an educational intervention, the values participants hold cannot be ignored. They should be highlighted and should themselves become the target of the educational program.

Rokeach's early work on values (1973) was used to identify participants' existing values. He defined and described 56 single values which were later classified by Schwartz and Bilsky (1987) into ten types: power (control), achievement, hedonism, stimulation, self-direction, universalism, benevolence, conformity, tradition, and security. As will be shown, three of these ten types are relevant to the conflict that was the focus of our program. *Power,* which represents control or dominance over people and resources, and *security,* representing safety and harmony of society. These two values are complementary and they both contradict the third type – *universalism,* which represents the desire to understand, appreciate, tolerate and protect all people and nature, or, in the terminology of the conflict at hand: the desire for peace.

Usually people are unaware of the values that govern the way they process information and construct their attitudes and behavior. This prevents them from considering their commitment to these values. Such an awareness can be gained when values are activated. According to Schwartz, 'it is in the presence of conflict that values are likely to be activated, to enter awareness, and to be used as guiding principles.' On this assumption, we decided to expose the values individuals hold by engaging them in a decision-making situation concerning a controversial dilemma related to the Israeli-Palestinian water conflict. Here is a brief description of this dilemma and the conflicting values that arise in making a decision in this matter.

*The dilemma of the mountain aquifer*

The mountain aquifer underneath the West Bank (Palestinian authority) is the major source of water serving both sides– Israelis and the Palestinians. It is an artesian aquifer that most of whose recharge area lies beneath the West Bank while its natural subterranean flow is toward Israel, where most of the springs and wells are located (Becker and Zeituni, 1998; Feitelson and Haddad, 1998; Gvirzman, 1994). Currently, this aquifer provides approximately 35% of Israel's annual fresh water consumption and virtually all the fresh water consumed by Palestinians on the West Bank. The total annual recharge of the mountain aquifer is estimated at 680 mm$^3$/year. Of this, Israel uses approximately 480 mm$^3$/year, and the Palestinians' draw is variously estimated at 110-180 mm$^3$/year (Kliot and Shemueli, 1998). The conflict is further complicated by the unequal per capita water consumption of the two sides. Palestinian per capita annual water consumption is less than a third of equivalent Israeli per capita consumption. High rates of population growth and forecasts of increased water consumption on the Palestinian side, the fact that all feasible freshwater sources are already being used, and the rapid development on the land covering the aquifer recharge areas (Feitelson and Haddad, 1998) only accelerate the problem.

Israelis argue that the water rights over this aquifer should be determined according to historical use of the water for over 50 years. Palestinians, on the other hand, argue that water rights over this aquifer should be determined according to territorial boundaries of the recharge area of the mountain aquifer. As it is situated in Palestinian territory, the water in the aquifer belongs to them (Gvirzman, 1994).

Ownership of the mountain aquifer water resources is, hence, not a settled matter. A possible solution to this conflict is to acknowledge the rights of both sides and to share the water.

Taking into consideration the information provided on this issue, participants were asked to come to a decision whether or not to share the water of the mountain aquifer with the Palestinians for the sake of peace. This creates a dilemma for the audience of the educational program.

The Oxford English dictionary defines a dilemma as a choice between two (or, loosely, several) alternatives which are or appear equally unfavorable. Lampert (1985) extends this definition to include choice 'between equally undesirable alternatives of action…' or 'between opposing tendencies within oneself' or 'between equally important but conflicting aims' (pp. 179, 182). She argues that as there is no 'right' alternative of action such choices are often not rationally decided. This view is supported also by Billig, Condor, Edwards, Gane, Middleton and Radley (1988) who claim that choice in a dilemma is not technical, but rather value-laden and that the conflicting values underlying dilemmas are

fundamentally borne out of a culture which produces more than one possible ideal world (p. 163). As such, dilemmas can be used to elicit a person's conflicting values. This type of activity became the core of the second education intervention which focused on several dilemmas that required decision-making (Dressler, 2002).

## An exemplary activity and the rationale of the second educational intervention

In this section we will illustrate and explain a model of eliciting the values inherent in the process of making decisions in dilemmatic situations (see example). This intervention follows seven stages of a decision-making model (Beyth Marom, 1991) described below:

*Stage 1: Introduction.* The mountain aquifer dilemma was presented in the context of water scarcity in Israel and neighboring countries and after dealing with the hydrological aspects of water management. Next, two alternative courses of action (to share the water or not to share) were offered to the students and they were asked to choose the one they prefer most and to state arguments for their choice.

*Stage 2: Developing Criteria.* At this stage suitable criteria for comparing the two courses of action were developed by using a consequence map strategy (Fullick and Ratcliffe, 1996). This strategy encourages students to think of the broadest possible range of consequences while considering the implications of each course of action. The question posed to the students was: What are the possible consequences of sharing (or of not sharing) the mountain aquifer water with the Palestinians for the sake of peace? Consequence maps were constructed by groups of students. As a result of the discussion following the construction of these maps, synthesis of these varying maps was carried out on the blackboard. Figure 2 presents an example of a class map reflecting the interpretation and understanding of both teacher and the students.

The key consequences i.e., the ones most students and teachers mentioned were classified according to their implications: ecological, political, health, economic, and security implications. These consequences were used as criteria for comparing the two alternative courses of action.

*Stage 3: Gaining Information.* At this stage students backed their consequence map with further information and clarified what was already known about each alternative with particular reference to the criteria just developed. The students

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### Decision-Making Activity

**To share or not to share the mountain aquifer water for the sake of peace?**

In the following activity you are going to experience a decision-making process on a controversial issue that engages the Israeli public: To share or not to share the mountain aquifer with the Palestinians.

1. Choose one of the following courses of action: (1) to share the water, (2) not to share the water. Back your decisions with thoughtful arguments.
2. Try and detail all possible answers to the following questions: What will be the consequences of sharing (or of not sharing) the mountain aquifer with the Palestinians for the sake of peace? Draw a 'consequences map' that reflects chains of consequences and interconnections between them.
3. Introduce your group's consequences map to the class for a discussion and with the aim of creating a class consequences map.
4. Classify the types of consequences into key-categories. These will serve you for analyzing the advantages and disadvantages of choosing each course of action.
5. Gather relevant information about each course of action with particular reference to the criteria just developed.
6. Organize the relevant collected information in the following table:

| Alternatives / Criteria | To share | Pro or Con | Not to share | Pro or Con |
|---|---|---|---|---|
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

7. State a choice that is based on the analysis undertaken in the previous stage. Back your decisions with thoughtful arguments relying on valid information.

</div>

were encouraged to gather information from any source they could think of. In addition, they were given some informative texts as a stimulus and hint for possible directions in their data search.

*Stage 4: Organizing Data and Judgment*. The students organized relevant information that was collected in a two-dimensional matrix of alternatives vis-à-vis criteria (see table in the work sheet presented). This allowed cross-evaluation of each alternative on each criterion. Every criterion was judged with respect to

*FIGURE 2: Class consequence map*
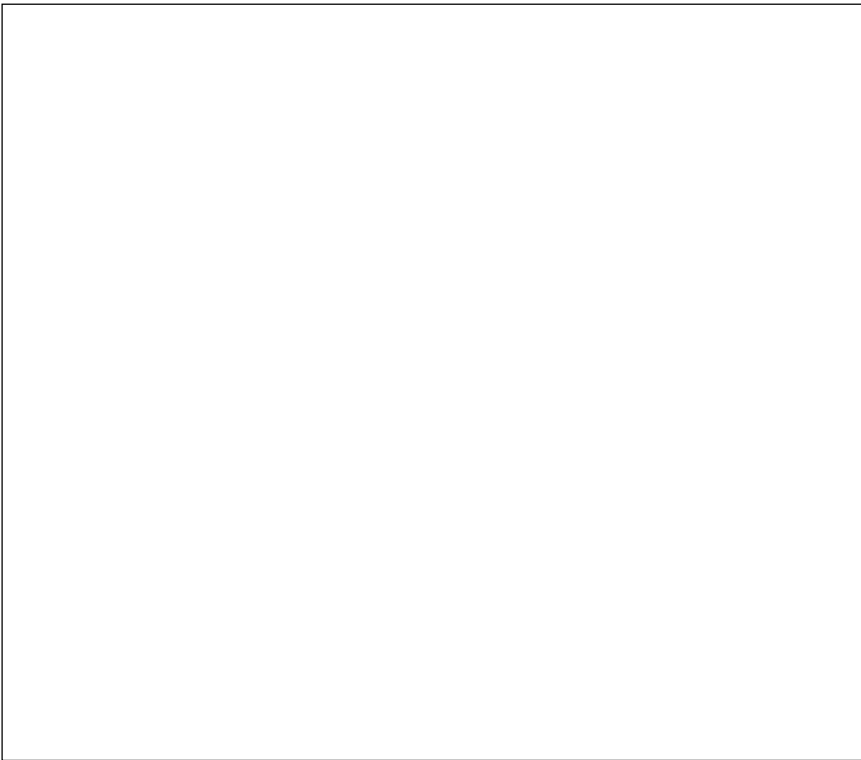


the alternative courses of action by identifying its advantages or disadvantages (pro or con).

*Stage 5: Stating Choice*. On the basis of the analysis undertaken, the students chose their preferred alternative without assigning weights[1] to the utility of the various courses of action and the probabilities of their occurrence. Engaging students with the above calculation is technical and could redirect students away from value consideration. After making their decision the students were asked to propose as many arguments as they could think of in support of their choice.

*Stage 6: Raising Arguments for their Choice*. Argumentation gives students an opportunity to reflect on the process they have gone through: Consider relevant evidence, re-evaluate their judgment and choice and come to reasoned conclusions

about the chosen alternative. In this stage the students were asked to raise as many arguments as they could think of to support their choice.

*Stage 7: Reflection.* Each group of students was asked to present their work to the class and to reflect on the process they went through while choosing their course of action. The presentation also served as a trigger for reflection for other members of the class.

## Results of the second educational intervention

The second educational intervention was carried out on three groups: students in non-religious Jewish schools, students in religious Jewish schools and students' schools for Arab citizens of Israel. We hoped that with the elaborated decision-making mechanism, would enable us not only to expose the values that govern participants' decisions, but also to make them change their prior decisions in light of this complex process. The results of such an experimental intervention were, again, quite disappointing. Only about one quarter of the participants changed their earlier decisions and only 15% out of them changed their decisions from not favoring the sharing of water to favoring it (for further reading, see Dressler, 2002). Underlying these decisions were of course, deeply embedded values. We tried to elicit these values by analyzing arguments the participants used in defending their decisions.

Here follows a brief description of the results: it consists of examples of common arguments given by the students and the corresponding, extracted values:

*Arguments used by the stable in favor groups*

### Jewish and Arab Israeli Students

| | |
|---|---|
| • We must give them water in order to promote peace. | *Universalism* |
| • Arabs and Israelis are equal human beings, it is impossible not to give water to thirsty people, we must think also about the others. | *Universalism* |
| • If we do not share the water, the next war will be the 'water war'. | *National security* |
| • Sharing water will create more opportunities for industrial development. | *Economic security* |

*Arguments used by the stable against groups*

## Secular Jewish

| | |
|---|---|
| • Water sharing will have negative effects on security | *National security* |
| • Palestinians are never satisfied with what they perceive as a result of peace treaties and always demand more and more | *National security* |
| • Sharing water with the Palestinians may damage the environment. | *Universalism* |
| • A peace treaty will not avoid terrorism; enemies will continue attacking us. | *National security* |
| • It is most important that we have full control over the mountain aquifer. | *Power (control)* |
| • Water sharing will have negative effects on the economy. | *Economic security* |

## Religious Jewish

| | |
|---|---|
| • If we give them a finger they will want the whole hand | *Power (control)* |
| • The mountain aquifer is part of Greater Israel | *Power (control)* |
| • Israel is the promised land, no-one can take this land from us | *Power (control)* |

## Arab Students

| | |
|---|---|
| • We prefer not having a peace treaty to dying form water scarcity | *Personal security* |
| • Sharing water will cause great shortage of water and therefore agriculture will be reduced and affect our standard of living. | *Personal security* |

Observing the consistency of the values that underlay the arguments of three-quarters of the participants, it became clear to us that the strategy used in our second educational intervention was not effective. When facing a decision-making situation which involves two conflicting values such as peace (a universal value) versus security or power control values, participants tend to store and

encode information in line with those values that are more central to their value system. Thus, those who were already convinced by the advantages of sharing the mountain aquifer with the Palestinians for the sake of peace, kept raising arguments that were based on universal types of values and on arguments that linked their decision to national security and economic prosperity; those, on the other hand, who from the outset were against sharing the water sources came up with arguments based mostly on power control (religious Jewish) or on personal security values (Arab students).

The cognitive approach failed for the second time in altering beliefs, attitudes and the values underlying them. In an attempt to understand what went wrong, we went back to Milton Rokeach's studies and his theory of value organization and change. According to this theory, long-range changes in values, attitudes and behavior are possible. They result from an objective feedback of information about one's own and others' values and attitudes. Rokeach presents evidence that such feedback made many participants conscious of certain contradictions in their own value-attitude system.

There was also evidence in Rokeach's work that the basic psychological mechanism responsible for value or attitudinal change was a state of self-dissatisfaction. This self-dissatisfaction occurred when a person gained awareness that certain of his or her values, attitudes or behaviors clash with or violate her or his self-conception as a moral human being. A person must then reorganize her/his value-attitude systems to make it more consistent with their self-conception (Rokeach, 1973, Rokeach and Grube, 1979, p. 242). An easily applied cognitive and behavioral change technique called 'self-confrontation' has been developed from this theory. This treatment is designed to provide individuals with information that will lead to awareness of chronic inconsistencies within their value system and their self-conception.

According to Rokeach, value education in schools should go in this direction. It should attempt to provide substantive information about the student's own values and about the values of others in their society in order to encourage students to compare what they find out about others with what they have found out about themselves. Such value education would encourage what John Dewey has called the experience of a 'felt difficulty' – a basic condition of learning and change and also a basic condition for realization of what are perhaps the ultimate educational values – individual growth and self-realization (Rokeach, 1979, p. 269). Value change thus is considered a long-term change tied to the process of education and re-education (Rokeach, 1968).

Reflecting on the step-by-step strategy we employed in our second intervention, we realized that it did not fulfill Rokeach's suggestions for self-confrontation. The strategy we used enabled us, as researchers, to map and

understand the values underlying individuals' decision-making and justifications. We even noticed contradictions and inconsistencies within participants' value systems. However, this knowledge was not shared with the students, i.e., they were allowed to remain unaware of these inner contradictions. The missing step is still ahead of us in planning what Rokeach calls a *self-confrontative tactic*. This will be the next stage of our project.

## Science education in the service of peace education

In this paper we described a more than seven-years project of peace education carried out mostly by science teachers. This is an instance of the Science Technology and Society (STS) approach in science education. In the final section, we would like to sum up our experience in teaching science as an integrated subject area and as a means of educating youngsters to be informed and responsible citizens, one of the most important goals of the STS approach.

Most STS-based curricula emphasize two interconnected domains: the *cognitive domain* (beliefs, attitudes, values), which refers to gaining knowledge and understanding on the interaction of science, technology, and society (Bybee, 1997; Ramsey, 1993; Yager and Tamir, 1993), and the *behavioral domain* which refers to developing social responsibility – active personal and social decision-making (Miller, 1983; Rubba, 1990). Rubba (1990) stated that the goal of STS education is to help students develop the knowledge skills, and affective qualities they need to take responsible action on the many social issues facing humankind. Hodson (1999) argued that it is not enough for students to learn that science and technology are influenced by social, political, and economic forces. They must also learn how to participate in real situations that require the use of the scientific and technological literacy needed for social and politically responsible actions.

Scientific and technological literacy has been defined in several ways, from grasping basic information and concepts needed to thrive in the modern world (Hirsch, 1987) through understanding the impact of science and technology on society, and finally, gaining the ability to act in a socially responsible way (Eisehart, Finkel and Marion, 1996; Miller, 1983). This ability to use knowledge in one's actions involves, according to Eisenhart et al. (a) understanding of how science-related actions impact the individuals who engage in them; (b) understanding the impact of decisions on others, the environment and the future; (c) understanding the relevant science content and methods, and (d) understanding the advantages and limitations of scientific approach. All these would be indicators of socially responsible scientific literacy (Eisenhart *et al.*, 1996, p. 284).

If this type of scientific literacy becomes the main goal of science education today then owing scientific knowledge becomes the basis for developing self-efficacy and for individual empowerment (Hungerford and Volk, 1990) or as Sylvia Scribner termed it, *ideal literacy,* referring to the 'simultaneously adaptive, socially empowering and self-enhancing' nature of scientific and technological literacy (1986, p.19). The knowledge-ownership-empowerment paradigm suggested by Hungerford and Volk (1990) implies the same meaning. In line with this broad view of science education, schools are encouraged to provide young people with real-world problems, equip them with essential skills – listening, arguing, making a case, accepting the greater wisdom or force of an alternative view – and then move to actions designed to resolve the problematic issues at hand. Yet how can young people learn how to make considered decisions about issues of a socio-scientific nature if their education in science and technology fails to provide them with the opportunity to practice the skills associated with argument by considering controversial issues (AAAS, 1993; Newton, 1999; NRC, 1996).

Several studies supported this broad and integrated STS approach in science education. Solomon (1992) reported that as a result of discussing controversial issues, students became more aware of their civic responsibility and more self-reliant in deciding on an issue. Hines et al. (1987) showed that citizens who had practiced on science and technology-related problematic societal issues were knowledgeable about the action that might be taken to resolve such issues; had the ability to carry out or take action needed for solving the problematic issues; and possessed certain personality and attitude characteristics that facilitated action. Similar results established through a decade of research in the USA, show that students' social responsibility is fostered by STS courses that involve them in real investigations of STS issues and attempts to resolve them (Ramsey, 1993; Rubba, 1990).

In broadening the scope of science education beyond the mere acquisition of scientific knowledge and habits of mind to include also the attainment of responsible modes of conduct, science education is empowered. When putting under scrutiny not only the validity of our knowledge, but also that of our beliefs, attitudes and values – the reasoned basis for our modes of conduct, we view science education as liberating and as contributing to the welfare of humans.

The Israeli experience, however, did not yield the promised outcomes. In spite of the success in enriching the participants of our two educational interventions with relevant information on the sources and consequences of the dispute over water resources and in spite of exercising decision-making in real relevant situations of scarce water management, only minor attitudinal change occurred in the desired directions and only a small percentage of participants changed their disposition to act or their predetermined decision in regard to sharing water resources with their Palestinian neighbors for the sake of peaceful coexistence.

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We have been enthusiastic throughout our project and are still highly emotionally involved as educators in the attempt to do something for peace in our roles as science teachers. Using the tools of science for learning the roots and possible solutions for an acute societal and political problem in trying to change students as well as our own perceptions about the conflict over water resources in our region and being involved actively in striving for co-existence of the two societies in conflict, made this teaching experience much more worthwhile for us. Hence, we cannot but feel frustrated when we hit the limits of our educational endeavor. It seems to us that if we do not find a way to make people question the values that govern their thinking, making decisions and processing information, we will not be able to persuade and educate our students to coexist and responsible citizenry decision-making.

In spite of our frustration and disappointment, this teaching experience was very rewarding and motivating. We intend to continue with this mission now using the self-confrontational approach in value education, in hopes to be more successful in changing the attitudes and intentions to act of young students in Israel.

## Notes

1. Assigning weights reflect a numerical value that represents how strongly the decision-maker prefers the outcome. For each outcome, its weight is multiplied by the probability of the proposition that the action would have that outcome and then summing them up and call the sum the action's expected utility.

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# BOOK REVIEWS

## Katarina Tomasevski, *Education denied; Costs and remedies,* London, Zed Books, 2003, 205 pp., pbk., ISBN 1 84277 251 1

This work by Tomasevski (2003) *Education Denied; Costs and Remedies* highlights the subtle yet all pervasive power of words. As I was reading this work I was reminded of the work of Foucault in the 1970s, famous for the assertion that 'systems of ideas become systems of power'. If systems of ideas do indeed become systems of power then as Tomasevski rightly points out, we cannot afford to be dismissive of mere word plays, jargon, political speak or political correctness in this day and age. Nor should these be lightly regarded or seen as innocent but rather they need to be seen for what they are, laden and decidedly political in nature. Especially so when these words erode the responsibilities or disguise the duplicity of the governments in countries who are suppose to up-hold and not abuse human rights or the universal human right to education. Words that are ostensibly supportive of human rights can at the same time be deceptive and deliberately misleading, bringing about significant paradigm shifts in policy, the ramifications of which can be far reaching and all pervasive.

The 'boom' of Tomaseveski's scattergun approach to writing in this particular work is highly effective in drawing and focusing one's attention to what are relevant and very important issues. I found myself challenged by the author's sobering insights into the political posturing that belies the disproportionate allocation of funds for the on-going support of education in various countries. More importantly, to the erosion of the hard won rights, as contested by our forebears for free and discriminate free basic education where the on-going commitment for funding is waning and increasingly being treated as discretionary. Tomaseveski examines the political manipulation of and by the World Bank which has exempted itself from the rule of law and instead talks of access to education and developmental objectives rather than a right to education. Furthermore the author correlates how global shifts in power, shifting fortunes of national wealth, differences in political ideologies between the Eastern and Western countries, national indebtedness and global inaction to address the problems of indebtedness have all shaped and eroded human rights in education. A key point being that education has now become a lottery that is more dependent upon individual and national wealth, the main question being: who will benefit, and who will miss out? Not content with tackling all of the above, Tomaseveski also addresses Islamic fundamentalism, religious/secular access arguments in education, evolution verses creationism debates and gender equality issues.

However the very nature of a scattergun is that it hits many targets at the same time, which leads to my only criticism of this book, that being, that there are a plethora of issues raised by Tomaseveski each of which warrant and cry out for a greater depth of development. The author does endeavour to address this by citing many relevant charts, graphs, statistics, and quotations to support the assertions made, nevertheless the copious quantity of all this supporting documentation tends to make for a disjointed reading of the text, which at times has the effect of derailing the readers' train of thoughts.

Nevertheless if Tomaseveski's intent is to expose as many issues as possible to the reader, than this book is an unqualified success. I for one am now much more aware of the broad scope of current issues that impact upon, threaten and violate what were once regarded as sacred cows in education. I am curious to find out more about these issues raised and will be much more vigilant and discerning about hidden agendas and the power of words.

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**Terence Portelli and Antoinette Camilleri Grima, *Stedina ghat-taghlim fis-Sekondarja* (An invitation to teaching in secondary schools), Dyad Publications, Malta, 2002, XV +396pp., ISBN 99932-0-163-4.**

Over the years, a number of books, focusing on different aspects of education, or on education in general, have been produced by scholars in Malta and Gozo, mainly scholars from the University of Malta's Faculty of Education. Most of them are written in the English language. This particular book, focusing on pedagogy, and written by two members of the University's Faculty of Education, who specialize in the teaching of Maltese at secondary level, is written in the native Maltese language. This is quite a rarity with respect to books on education published in the Maltese islands.[1]

In this book, the authors of *Stedina* demonstrate the Maltese language's suitability for use in academic and other specialized areas. In so doing, they make an important contribution to the development of the Maltese language itself; they enrich the language through the coining of new terminology and formulation of phrases suited to the pedagogical field. The authors also provide, at the end, a glossary of terms used throughout the volume.

One of this book's strengths is that the authors render the material as accessible as possible to prospective and fully fledged teachers in Malta. Not only is this text written in elegant Maltese prose but a great pedagogical effort is made to consolidate the main concepts, conveyed in the respective chapters, through questions intended to stimulate reflective thinking and further discussion. The authors also supplement the various chapters with appendices providing, among other things, a collection of useful teaching aids.

In its focus on the needs of prospective Maltese and Gozitan teachers at secondary level, this work ought to be read alongside another set of volumes edited by members of the University of Malta's Faculty of Education (Christopher Bezzina, Antoinette Camilleri Grima, David Purchase and Ronald Sultana), namely *Inside Secondary Schools. A Maltese Reader* and its accompanying workbook (Indigo, 2002). There is some overlap between the Reader and *Stedina* especially with regard to issues concerning assessment, classroom management, the curriculum and the concept of the reflective practitioner. Nevertheless there is sufficient material in either of the two books that are not to be found in the other. This renders the two works quite complementary.

*Stedina* deals with the following aspects of teaching at secondary level: school and classroom observations by student teachers; the learning environment; the Curriculum, Syllabus and Attainment targets; the process of planning

lessons; preparation for teaching; considerations concerning language skills; considerations concerning language teaching; classroom communication; learning resources; pupils' work; the use of the Maltese language in the Maltese educational system.

These aspects of teaching are given their due importance in the pedagogical work, concerning the initial formation of teachers, provided by the University of Malta's Faculty of Education. Through its lengthy and in-depth discussions, this book provides the rationale for some of the approaches advocated by the Faculty with which student teachers and practising teachers are by now quite familiar. One of the challenges in works such as this is to extend the discourse beyond the current teacher-education framework. For instance, there is little discussion concerning the way prospective teachers can engage in preliminary research to create a 'profile' of the specific community, or communities in the case of secondary school teachers, in which they would be expected to carry out their teaching practice. In my view, the gaining of insights, through systematic research by educators, regarding the surrounding school community/ies should be an important feature of the development of schools as 'community learning centres', as advocated by the new National Minimum Curriculum (henceforth NMC) document tat was launched in Malta in 2000. Admittedly, this is more likely to occur in a primary school context in Malta and Gozo than in a secondary one, given that the former type of school draws pupils from the immediate surrounding locality while secondary schools have a larger catchment area; in the case of Gozo, the secondary school draws pupils from all over the island.

The authors incorporate, in the various discussions, which draw on some of the pertinent literature in the field, the insights of fully-fledged and student teachers serving as reflective practitioners. This is no doubt intended to ensure that the various discussions are grounded in some of the realities of classroom practice, though there is always a tendency in books of this kind, meant to inspire the prospective teacher, to provide a somewhat idealistic view of the classroom situation. In my view, some ethnographic data revealing the 'messy' issues teachers confront in the everyday classroom situation, and the trying circumstances in which they carry out their work, would have enhanced the book.

The authors provide amplified discussions on the three important aspects of the educational process, namely the Curriculum (specific reference is made to the NMC document), the Syllabus and, when applicable, Attainment Targets ('Skaluni' in Maltese). The discussion on 'Attainment Targets' is particularly important and timely with respect to the current process of implementation and development of the NMC document, arguably the country's most important contemporary 'consensus' educational policy document.

While Terence Portelli and Antoinette Camilleri Grima deal with general themes, concerning education at the secondary school level in Malta and Gozo (a feature of *Inside Secondary Schools*), therefore rendering their book relevant to the secondary school teacher in general, they recognize that subject specialization is very much a feature of secondary school teaching. They manage to provide a concrete example of the way most of the issues they address in this book are brought to bear on the teaching of a specific subject. In this regard, they play to their strengths by focusing on the teaching of Maltese They also do this within the context of a broader discussion on language teaching in general, therefore widening the book's appeal. The book should therefore be of relevance not only to teachers of Maltese but also to teachers of other languages in the Maltese archipelago and, given the wide range of issues discussed, Maltese and Gozitan secondary school teachers in general.

The chapter in which the authors outline the most important landmarks in the struggle for Maltese to attain its present hard-earned status in the Maltese educational system is one of the strongest in the book and provides a fitting conclusion to the volume. An insightful discussion on the uses and misuses of Maltese and its variants is provided. The authors also touch on the issue of the respective uses of English and Maltese as languages of instruction for other areas in the Maltese education system, without, however, providing any discussion on the broader socio-political and pedagogical implications of the choices made by teachers and policy makers in this regard. Is the choice of English as the language of instruction and assessment in such areas as Maths and Sciences detrimental to the educational achievement of certain pupils and beneficial to others (Maltese is the popular native language while traditionally English has been the language of academia)? Is there a social class factor involved here? Does the NMC document address this issue adequately?

The NMC document is constantly referred to in *Stedina*. I would argue that this policy document's recommendations constitute the framework for many of the discussions provided by Portelli and Camilleri Grima. The book therefore should serve as an important source of reference to those involved in the development of the NMC. There is however very little critical engagement, by the authors, with some of the tenets of the NMC document and this is rather surprising given that Antoinette Camilleri Grima raises a number of queries, in *Inside Secondary Schools*, with respect to the NMC's recommendations regarding which language ought to be used as medium of instruction for specific subjects. A similar critical stance concerning the NMC is not to be found in *Stedina*. The final chapter dealing with the use of the Maltese language in the Maltese educational system could have lent itself to a critical engagement of this sort.

The authors draw on a broad range of writings to provide the theoretical framework for the discussion of several topics. The extensive list of references at the end testifies to this. The research drawn upon is both Maltese and foreign. The criticisms made earlier should not, in any way, detract from the value of this book which has been painstakingly put together, is very insightful and well researched and should serve as a source of inspiration to prospective and practising teachers in Malta and Gozo. The volume represents a very important contribution to the ever-growing literature on education in these islands.

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1. Malta is an archipelago of islands of which Malta, the largest island, and Gozo are the two substantially  inhabited ones. The native language across these islands is Maltese. English has traditionally been used as the language of instruction and assessment in various educational establishments.

## Notes for Contributors

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The manuscript can be submitted as an e-mail attachment, to be sent to: ronald.sultana@um.edu.mt Alternatively, **three** complete copies of the manuscript can be submitted, typed double-spaced on one side of the paper. A diskette version of the article (preferably formatted on Word for Windows) should be included with the manuscript.

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**References** should be indicated in the text by giving the author's name followed by the year of publication in parentheses, e.g. '...research in Mahmoudi & Patros (1992) indicated...', alternatively this could be shown as '....research (Mahmoudi & Patros 1992) showed...'. The full references should be listed in alphabetical order at the end of the paper using the following formula:

*Book:* Surname, Name initials (date of publication) *Title of Book*. Place of Publication: Publisher.

*Article in Journal:* Surname, Name initials (date of publication) Title of article, *Title of Journal*, Volume(issue), pages.

*Chapter in Book:* Surname initial/s, Name initials (date of publication) Title of chapter. In Name initials and Surname of (editor/s) *Title of Book*. Place of Publication: Publisher.

Particular care in the presentation of references would be greatly appreciated, and ensure earlier placement in the publication queue.

Proofs will be sent to the author/s if there is sufficient time to do so, and should be corrected and returned immediately to the Editor. 25 offprints of each article will be supplied free of charge together with a complete copy of the journal issue.

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