Science and Technology links in Israeli Secondary Schools - Do We Have a Reason to Celebrate?

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Introduction

"Communities of technology and science educators have been passing as two ships pass silently in the night without speaking to each other about their relationships." (Zuga, K. in Yager, 1996)

There is wide agreement in Israel that appropriate scientific and technological literacy should be provided to every boy and girl at all levels of their education. Since 1996, technology and science curricula the in Israeli junior high schools (grades 7-9)have been combined in one mandatory curricula subject: "Science and Technology". Although, to some extent, and in some schools, different kinds of relationships between science and technology teachers exist, the collaboration between science and technology on a state level is more wishful thinking than reality. In this paper I suggest that the lack of clear conceptual pedagogical frameworks within the curriculum has been one of the obstacles for effective integration/collaboration of science with technology. In order to cooperate effectively, science and technology educators have to speak to each other on the basis of agreed and well defined conceptual pedagogical frameworks. Such frameworks are essential for the implementation and diffusion of the "Science and Technology" curriculum. This paper starts with a review of the literature on different models of collaboration/integration, and goes on to describe the current situation in Israel with regard to the implementation of the national curriculum. Finally, a possible conceptual framework (curriculum organizer) for relationships between science and technology is suggested.

Keywords: Curriculum Development, Problem based learning, Collaboration, Integration, interdisciplinary.

Note: this paper reflects a personal view of the author, based on ten years of experience as a curriculum developer, teacher trainer, and coordinator for implementation of the curriculum.

Review of Literature

There has been much discussion about the relationship between teaching/learning science and technology resulting in a diversity of views. At one extreme, science and technology are regarded separated and independent, while at the other end of the spectrum; they are seen as one integrated subject.

Some strongly support linking science and technology in education arguing that this increases student motivation and enhances learning (Sage, 1993; Loepp. F.1995; Laporte & Sanders, 1993; Sanders, 2000). This is also seen as a way to establish technology education as a vital addition to the public school curriculum (Linnell , 2003). Others provide a rationale for the separation and independence of the two subjects in the curriculum (De Vriez, 1996; Williams, 2002; Barlex & Pitt, 2002), and question the contribution for technology education of combining them together (Foster, 1994; Foster, 1995).

This review focuses on various models for integrating science and technology.

STS (Science-Technology-Society) programs started to flourish in the early 80's as a new approach for science education (Yager, 1996; Aikenhead, 1994). This programs had been criticized, claiming that they were mainly a new type of science education (Foster, 1995), and that the technology aspects were not represented properly (Layton, 1993).

- Rubba (in Yager, 1996) suggested an explanation for the failure of integrating technology in science class:- *"one could not expect that science teachers without proper background and experience in technology would be able to implement an integrative approach".*

Daugherty & Wicklein (1993) found that science and mathematic teachers has stereotypes perception about technology education. They recommended workshops for science and technology teachers to present to them the potential of the technology education in order to cooperate effectively.

From the mid 80's technology educators began to explore and develop programs and curriculum materials that linked technology and science (Black & Harrison, 1985; De Beurs, 1998; Raudebaugh, 2000) and even integrated them with math education (MST, 1996: IMaST, 1995; MSTe, 1999).

While some have described such programs as effective and successful (Gloeckner, 1991; Kain, 1993 in Loepp 1995), others reported that they did not find any significant contribution with regard to improving technology problem solving (Childress, 1996), or generally found differences to be insignificant (Dugger & Johnson, 1992; Dugger & Meier, 1994; Scarborough & White, 1994).

Sage (1992) proposed a Technology *Led Model* for collaboration that is characterized by the relations between the technology activities and the scientific knowledge that is required as support in order to solve a problem. He defined three levels of support relations:

- Essential and specific scientific knowledge that is needed in order to solve the problem.
- Practical scientific knowledge that is related to the technology activity and might be relevant in order to solve the problem (can be taught in the science class).
- Opportunities to develop extra scientific knowledge based in the relevancy and motivation (in science class).

The Mste Project (Hacker, 1999) described three models that schools across the state are using to integrate science, mathematics, and technology instruction.
Model 1 - Individual teachers help students make explicit connections between what they learn in a particular M, S, or T class and what they are learning in other classes.
Model 2 – Teachers work together to develop interdisciplinary units.
Model 3 – A fully integrated approach. Students are either block scheduled into three periods of mathematics, science, and technology or to an integrated course where teachers team teach.
Barlex & Pitt (2000) described three possible relationships between science and technology in education : Co-ordination, Collaboration and Integration. Their report

supports co-ordination and collaboration among the subjects but rejected integration.

Those who have supported linking the subjects, have identified factors that significantly affected the success or failure of the multidisciplinary curriculum: a new constructivist teaching approach combined with authentic assessment methods (Loepp,1995), teacher and administration commitment to the integrative approach (Wicklein & Schell, 1995; Loepp,1995)or the ability to organize and coordinate the activities among the teachers from the different subject matter (Sanders, 1996).

Layton (in Sage,1992) claims that one of the difficulties in implementing collaboration is the dual roll of science, from an autonomous subject which has its own goals, to a subject that serves technology as part of the collaboration.

On a broader level, few states have Science and Technology as a combined curricula's subject – Israel (1996), Massachusetts (1999) and New York (Hacker, 1999). In Australia (New South Wales), Science and Technology is a single learning area in primary school and then separated in secondary education.

In short, the review shows that there is a potential to enhance learning, but difficulties in implementation accompanied with doubts on the contribution of the integration continue to exist.

Technology Education in Israel – Rationale and Content

There is wide agreement in Israel that appropriate scientific and technological literacy should be developed in every student at all levels of education.

Since 1996 technology and science curricula in Israeli junior high school (grades 7-9) are combined in to one mandatory subject: "Science and Technology".

The rationale for the linkage is expressed as follows:

> "*…. Collaboration between science and technology is essential because of the growing linkage between scientific subjects and relevant technologies and also because of the unclear borders between them."*
>
> (The Israeli National Curriculum for Science and Technology, 1996. p.5)

According to the new curriculum for junior high schools, 540 hours of instruction will be provided to all students in the following main subjects (table 1):

Table 1: Main subjects

Main Subjects	Hours : grade 7- 9
Materials: Structure, Function and Processes	105
Energy and Interaction	90
Technological Systems and Products	90
Information and Communication	30
Earth and Universe	45
Phenomena, Structures and Processes in Living Organisms (with special emphasis on the human body)	150
Ecological Systems	30
	540

Although it has been established as a combined curriculum (Science and Technology), it is recommended that there should be different teachers who specialize in different subjects of the curriculum and who will collaborate within teamwork structure. However, **no clear conceptual pedagogical framework for such collaboration is specified in the national curriculum.**

On one hand, the curriculum emphasizes an inter-disciplinary approach:

> *"Teaching the subject matter according to this inter-disciplinary approach which characterizes the contemporary approach of science and technology teaching, will expose the student to science and technology aspects, and will introduce the social connections while emphasizing the combination between them".*
> (The Israeli National Curriculum for Science and Technology, 1996.p.6)

On the other hand, the relationships should be established while maintaining the knowledge structure of each subject matter (physics, biology, technology, etc,), and avoiding associative connections.

> *"Examining different teaching models that integrate science and technology reveals diverse existing possibilities of combining and integrating subjects…"* (The Israeli National Curriculum for Science and Technology, 1996.p.11)
>
> *"…it is worthy mentioning and emphasizing that the inter- disciplinary approach will be expressed in those cases in which the connections derive from the essence of the subject, while avoiding compulsory associative connections".*(The Israeli National Curriculum for Science and Technology, 1996.p.5)

Strangely here, "different teaching models", "diverse existing possibilities", and "avoiding compulsory associative connections", are not specified in the curriculum. In fact, it is left to each school to decide.
In order to understand the whole picture, two more points are worth mentioning:
1. differences in the statues and in the attitude toward science and technology.
2. Differences in academic background of science and technology teachers.

Teacher Training

Due to the new curriculum, a national in-service teacher training program was held in regional centers and academic Institutions.
The programs included: main subjects of the curriculum, instructional strategies, and project based learning and team working.
While most of the science teachers focused on the scientific subjects with whom they were familiar, the technology teachers had to move from the craft/industrial art approach to learning new concepts: design and systems. This process had been done in order to establish and facilitate a new framework for technology education.

Bar Josef (2004) reports on the impact of such training programs on the teacher's practicum. Science teachers point to the following features as those which have had the most significant positive contribution:

- Their perception of the links between science and technology.

- Their perception of team working.
- Their perception of their ability to teach technology.

Although the in-service training programs has a positive contribution on their ability to teach technological aspects (mainly design), they do not feel skilled enough to teach those aspects.

Development of Curriculum Materials

Several Institutions were responsible for developing curricula's materials, according to the following guidelines:

> *"Examining different teaching models that integrate science and technology reveals diverse existing possibilities of combining and integrating subjects…"*
>
> (The Israeli National Curriculum for Science and Technology, 1996.p.11)

As the "different teaching models" and "diverse existing possibilities" were not specified, different approaches to the science–technology relationships were presented. Science oriented curricula's materials (mainly textbooks) emphasized the scientific world (scientific knowledge, inquiry methods and skills) while technology was presented mainly through measurement tools and systems that are essential for conducting a scientific inquiry. Some of these materials presented technological concepts such as design, but they did not encourage the actual "doing" aspects. This approach was embraced by science teachers.
Technological oriented materials (mainly textbooks) emphasized the design process and the system approach as primary concepts of technology, as well as the "doing" aspect of technology but lacked scientific segments (scientific knowledge and skills). This approach was embraced by technology teachers.

Diffusion

In the first four years of implementation, due to the massive in-service teacher training program and new curricula's materials that had been developed for all the main subjects, most of the technology teachers made the transition to teach design and systems (see in table 1:Technological Systems and Products)**.** The learning environment consisted of Project Based Learning using mainly LEGO for learning systems (fig .1) and "soft" materials for the design and make (fig. 2).

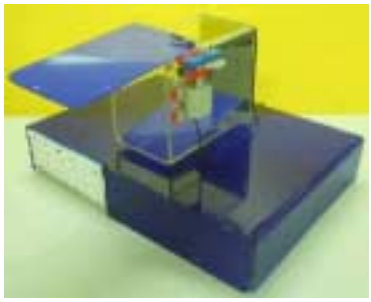


Figure 1: LEGO model of a mouse trap

Figure 2: Prototype of a chair with a drawer

In most schools, relationships between subjects were characterized *by coordination*; the technology teachers were responsible for teaching technological subjects (systems and products) while science teachers were responsible for scientific subjects (energy, living organisms, etc.). On this level the teachers were informed what the others are teaching.

In some schools the relationships between science and technology were established around *collaboration* on one of the subjects, mainly on materials. Design, for example could be utilized in the selection of materials. The science teacher focused on teaching the structure of materials (the atomic model) whiles the technology teacher focused on design and the choice of materials in the framework of actually producing a model or a prototype.

Some schools organized the relationships between science and technology around social topics: waste, pollution or water problems in Israel. This appealed mainly to science teachers. Usually on this kind of projects, the technological aspects were reduced to mentioning different available solutions (technology as applied science).

Several difficulties were encountered in Israel; some are similar to those mentioned in the literature review; others are unique to the Israel scene:

- No clear perception in the curriculum about the relationships and ways of linking science and technology.
- No required commitment of teachers and subject coordinators to coordinate/integrate/collaborate. Thus, links between science and technology emerged as school initiatives.

- Lack of appropriate curricula's materials for collaboration/integration and insufficient scientific knowledge among the technology teachers appear have had a little impact on the integrating of science in classroom practice.

In the last four years, science and technology classes have been reduced from 6 to 3-4 hours per week. As a result, in many schools the technology education (as part of the unified curriculum) is in a decline. In some schools the technological subjects does not exist; in others, where the technological subjects still exist, some of them are taught by science teachers. Still, a conceptual frameworks for collaboration/integration is lacking.

Frameworks for Relationships

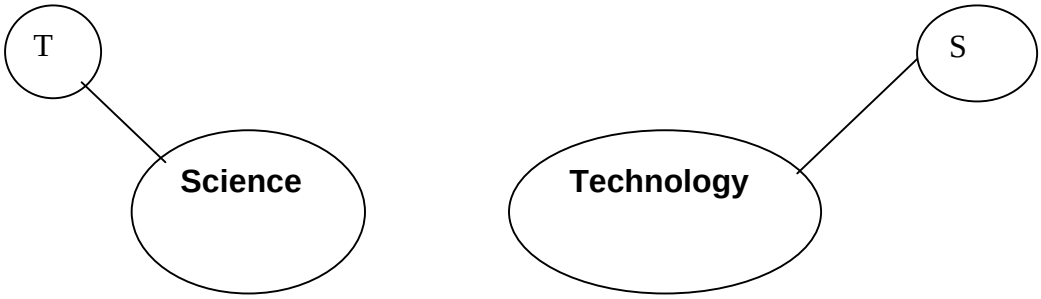
How should schools integrate between science and technology and yet preserve the underlying concepts of each discipline?

Due to the principles in the national curriculum, collaboration on one hand, and preservation of disciplinary subjects on the other hand, we suggest two parallel frameworks of relationships:

Framework 1: Connections within each discipline

Individual teachers in each discipline can help students make explicit connections between what they learn in a particular science or technology class and what they are learning in other classes (fig. 3).

Figure 3: Explicit Connections



According to Barlex (2002) this kind of links has a little impact on class practice.

> *"Curriculum materials designed to encourage pupils to use science in design and technology lessons appear to have had a little impact on classroom practice. Curriculum materials designed to enable science teachers to use technological*

context to motivate students and improve learning appear to have had only limited uptake". (p. 6)

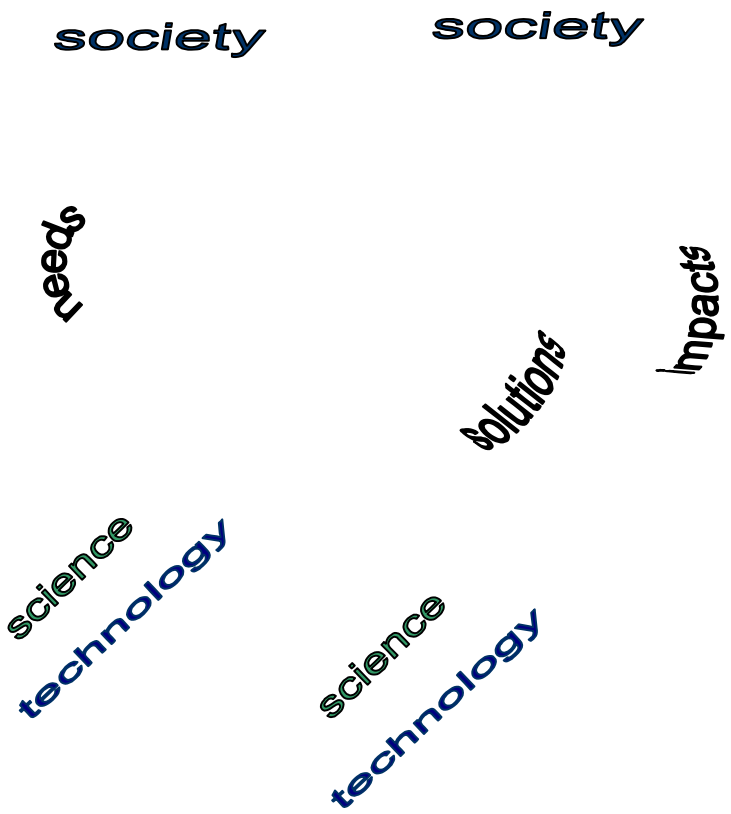
The description above present the current situation in Israel. It certainly does not do justice to technology education in science classes and to science education in technology classes, but it enables both disciplines to preserve and maintain their own disciplinary structure.

Framework 2: Collaboration/Integration among discipline.

Collaboration means that teachers of each subject plan their curricula so that some but not all activities within each subject are design to establish an effective relationships among the subjects (Barlex & Pitt, 2000). Practically, Teachers from both disciplines collaborate through integrated projects. The projects focus on problem-solving in a social context (Krumholtz,1998). Each aspect of the project is led by a teacher who is the most skilled in a specific segment.

The collaboration is based on a didactical model for collaboration between the disciplines, known as the **STSS** (**S**ociety-**T**echnology- **S**cience- **S**ociety) model.

Figure 4: The STSS- Model



The STSS Model is supported by four elements:

- Problem solving.
- The use of social, scientific and technological knowledge for problem solving and decision-making.
- The view that science and technology are two distinct but interacting disciplines.
- Utilization of the gap between the needs of society and reality as a "driving force" for developments in science and technology.

This model can help science and technology teachers to collaborate and exploit their capabilities and strength. Science teachers focus on science aspects of the projects while technology teachers focus on technology aspects of the projects. for example, Starting with an issue in **society** such as "The noise around us" (Kipperman, 2003) leads to finding out about the nature of sound and noise through a set of learning activities that develop understanding of key science concepts (**science** teachers). Using tools to record noise and analyze different existing systems that create noise and different existing systems to reduce noise (**technology** teachers). **Science** investigations leading to using this understanding as one of the resources to solve the problems created by noise by developing(designing) solutions (**technology** teachers) appropriate for particular contexts and evaluating the impacts on the **society** and the environment.

The following (table 2) is an example for collaboration among teachers (physics, biology, technology) in organizing lessons plan for teaching the unit.

Table 2 : lessons collaboration

Timeline	Technology Teacher	Science Teacher	Types of activities
First week	Introducing situations, Identifying needs & problems		
		x	Gathering information
Second & Third week	x		Gathering information
		x	Scientific inquiry
	x		Technology inquiry
		x	Scientific inquiry

Forth week	x		Brainstorming for solutions
		x	Further investigation according to the specific area
Fifth week	x		Make and evaluate the solution
	Presentations of projects		

This framework is similar to models that are presented in the Literature review: (Sage, 1992; Raudebaugh, 2000). Based on evidences from the literature (Loepp, 1995; Laporte & Sanders, 1993), we believe that such a framework facilitate meaningful collaboration which is based upon the capabilities and strength of the teachers in each discipline.

Both frameworks as a whole, will enable science and technology teachers to teach their subjects as an autonomous subject which has its own goals (framework 1), and collaborate as two disciplines that serve society (framework 2).

Discussion & Summary

The science and technology curriculum in Israeli junior high schools (grades 7-9) are combined into one mandatory curriculum subject: "Science and Technology". So…do we (in Israel) have a reason to celebrate (with regard to collaboration)?

On one hand, the new combined curricula were a corner stone. It served as a driving force to shift from craft and industrial art to technology education which emphasizes skills such as problem solving (design process) and system approach. In addition, the linkage between science and technology in education has the potential for enhancing technology education as an integral component in the Israeli general curriculum.

On the other hand, the current situation is that collaboration between science and technology on a state level is more wishful thinking than reality. Technological aspects of the curriculum are not delivered properly within the collaboration, and do not do justice to the real relationship between science and technology.

It is clear that there are no one simple and general solution to the problems confronting those who attempt to establish productive relationship between school science and school technology. This paper focuses on the lack of clear conceptual

frameworks within the curriculum as an obstacle to collaboration within one combined subject. Conceptual frameworks are essential for the implementation and diffusion of "Science and Technology". Therefore, the first step needed is a dialog between science and technology educators in order to be clear about the goals of the collaboration and establish agreeable conceptual frameworks that will serve as curricula's organizers for interactions between science and technology teachers. The didactical frameworks for relationship presented in this paper have the potential to serve as one platform for productive collaboration.

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