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An Analysis of the Technology Education Curriculum of Six Countries

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Introduction

The government of Finland has begun planning a new national curriculum framework for the comprehensive and upper secondary schools. The aim of this study was to find information that could be used in establishing a theoretical basis for planning the technology education curriculum. In order to define the scope and focus of each curriculum element (e.g., rationale, theory, objectives, methods, content, and means of evaluation), the technology education curricula of six different countries were studied: Australia, England, France, The Netherlands, Sweden, and the United States. The rationale for choosing these six countries was that their technology education programs have developed rapidly over the past ten years and profound research, experimental programs, and the development of learning materials have been undertaken, especially in Australia, England, The Netherlands, and the United States. The aim was not to conduct a comparative study of the curricula of other countries. Rather, it was to synthesize theory and practice. A secondary aim was to search for more detailed and concrete curriculum materials for provincial, district, municipal, and school purposes. Although this research was conducted to support Finnish curriculum development, the results may be pertinent to other countries as well.

Different countries use different terms to describe technology education, such as technics, design and technology, technology education, and technological education. In this study these titles were considered to be synonymous. Regardless of the term used, the universal goal is to help students to become technologically literate.

A model was developed so that the technology education curricula of the selected countries could be systematically analyzed and the important curricular elements could be identified. Assessment practices were not included in the study, although Kimbell's (1997) work in this area must be recognized since he included most of the countries reported herein.

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The analysis is presented in two phases. First, the curricula of the six countries are summarized. The goal at the outset was to cross tabulate the elements from the curricula; however, it was found that the countries differ to such degree that it was impossible to reach this goal. Curriculum guidelines of the six countries are, however, presented so that the reader can obtain a general understanding of the different curricula. Following this, all six countries are examined more closely using a method of systematic analysis in order to identify both common and unique features of their curricula.

Curricula Overview

According to Madaus and Kelleghan (1992, p. 128), a curriculum consists of six components: 1) content 2) general objectives 3) specific objectives 4) curriculum materials 5) transaction 6) results. These components served as one dimension of comparison for the study. A second dimension used three elements: rationale and content, implementation goals, and other observations.

The primary sources for curriculum information in this study were:

Australia	*A statement on technology for Australian schools, A joint project of the States, Territories and the Commonwealth of Australia* (Australian Education Council, 1994).
England	*Design and technology in the National Curriculum 2000* (Qualifications and Curriculum Authority, 2000)
France	*Noveaux programmes de 6e* (Ministére de l'Education,1995) *Noveaux programmes du cycle central* (Ministére de l'Education, 1997)
The Netherlands	*The new core objectives for the subject technology in the Netherlands* (Huijs, 1997) *Development of technology education* (deVries, 1999)
Sweden	*Kursplaner för grundskolan* (Utbildningsdepartement, 1994)
United States	*Technology for all Americans: A rationale and structure for the study of technology* (International Technology Education Association, 1996) *Standards for technological literacy: Content for the study of technology* (International Technology Education Association, 2000).

All of these documents were regarded as nationally accepted guidelines for technology education within the countries concerned at the time the study was conducted.

The Technology Education Curriculum of Australia

In Australia, technology is one of eight subject areas studied in schools. Technology is divided into four content areas, called strands: designing, making,

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and appraising; information; materials; systems. The strands are considered to be interrelated and are the basis for curriculum monitoring, revision, and reform.

Rationale and Content

The curriculum is based upon the rationale that people face technology everyday and therefore they must learn about it.

National Goals

The overall goal is to respond to the current and emerging economic and social needs of the nation and to provide those skills which will allow students maximum flexibility and adaptability in their future employment and other aspects of life. This includes the development in the student of:

- Skills of analyzing and problem solving
- Skills of information-processing and computing
- An understanding of the role of science and technology in society, together with development of scientific and technological skills
- An understanding of and concern for a balanced development of the global environment
- A capacity to exercise judgment in matters of morality, ethics, and social justice

The Importance of Technology

Through the study of technology, people will become more innovative, knowledgeable, skillful, adaptable and enterprising. This will enable people to:

- respond critically and resourcefully to challenges
- devise creative ways of generating and applying ideas
- translate ideas into worthwhile outcomes
- find innovative solutions to community needs
- focus on the design of techniques and products
- deal with uncertainty in an informed way
- cooperate in flexible teams
- appreciate cultural differences
- learn throughout their lives
- use local, national, regional, and international networks

Implementation Goals

Technology is to be included as one of eight broad areas of study:

1. the arts
2. English
3. health and physical education
4. languages other than English
5. mathematics
6. science

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7. society and environment
8. technology

The theory and practice of technology are integrated. Study is to be interdisciplinary. Technology involves the development and application of ideas and principles from other areas of learning such as the applied sciences, engineering, and business and commerce.

Technology should be studied by both girls and boys during the compulsory years of schooling (years 1-10). Secondary school programs are more specialized, often leading to discrete programs as students progress toward year twelve. In upper secondary years, many technology programs focus on further education and life and work outside school.

Other Observations

Technology programs can be structured and delivered either as discrete programs or combined with other areas of learning. Technology programs in primary schools give students a broad foundation for further learning. They are taught by classroom teachers, sometimes in association with specialists or resource people, with varying allocations of time to allow different activities. In the secondary school, technology education includes a number of different areas of study.

- agriculture
- computing/information technology
- home economics
- media
- industrial arts, manual arts, design and technology

The Technology Education Curriculum of England

The National Curriculum in England was revised in 2000 and will gradually become statutory over a three-year period. Compulsory schooling is divided into four Key Stages. Key Stage One (grades 1-2, ages 5-7) and Key Stage Two (grades 3-6, ages 8-11) concentrate on English, mathematics, science, design and technology, information and communication technology (ICT), history, geography, art and design, music, and physical education. In Key Stage Three (grades7-9, ages 11-14) and Key Stage Four (grades 10-11, ages 14-16), citizenship and modern languages are added, with one language required.

Rationale and Content

The overall rationale for design and technology education is the need to prepare pupils to participate in tomorrow's rapidly changing technologies. Through technology education they learn to think and intervene creatively to improve the quality of life. They become autonomous and creative problem solvers, as individuals and as members of a team. Through needs, desires, and opportunities they develop a range of ideas in order to design and make products and systems. They combine practical skills, aesthetics, social and environmental

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issues, and reflect on and evaluate present and past design and technology, its uses and effects. Through design and technology they become innovators and discriminating and informed users of products. Specifically, pupils should be taught to:

- develop, plan, and communicate ideas
- work with tools, equipment, materials, and components to make quality products
- evaluate processes and products
- know and understand materials and components

The specific objectives become more demanding with each higher Key Stage. At Key Stage Four one more objective is added: to know and understand systems and control.

Implementation Goals

Technology is one of the core subjects in the schools and is to be studied by both girls and boys. A national examination is required, resulting in a General Certificate of Education upon completion of compulsory education. Technology education is to be integrated where convenient, for instance with the arts, mathematics, and science.

Other Observations

There are nine attainment levels that become hierarchically more difficult. Very specific information on the quality of pupils' performance is included. The specifications for the ninth level are very rigorous.

The Technology Education Curriculum of France

Technology education is a compulsory subject for the four years of the junior secondary level (ages 11-15). At the time of the study, there is a detailed curriculum only for class levels six (11-12 years, adaptation level), five (12-13 years, first central level), four (13-14 years, second central level) and three (14-15 years, orientation level). A specific plan was not in place at the primary level.

Rationale and Content

Technology education aims to clarify the interconnections among work, products, and human needs, and the effects of technology on society and culture. When studying technology, pupils must face concrete situations requiring application of know-how and implementation of skills. These skills are enriched during the study process. Specifically, technology education gives pupils an opportunity to:

- become acquainted with technical systems, their implementation and use
- learn to use the correct language of the discipline

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- become acquainted with the special methods of technology, where a variety of solutions can be found for a specific problem
- learn how to use developed expertise in different situations to solve a problem
- use equipment and control systems in a rational way, by following safety precautions and the laws of ergonomics
- observe development, different means of production, and different technical solutions to a similar technical problem
- observe and build connections between the schools and enterprise
- take a critical stand and participate in the technological world without emotional obstacles

In primary schools, simple mechanisms, electric plans, energy production, and production in general are studied. Students engage in small projects, particularly those using computers. In secondary schools, production, marketing, needs analysis, and professions in production and service are covered. Experience with applications of CAD/CAM is also included.

Implementation Goals

Integration with the French language is considered particularly important. This includes terminology, word processing, critique of commercials, and wise consumerism. Relationships among the French language, science, and social studies, with considerable emphasis on computing, are stressed. The time devoted to the study of technology range from 90 to 120 minutes per week. Technology education is to be studied by both girls and boys.

Other Observations

Technology education is taught by class teachers at primary level and subject teachers at secondary school level. The aim is to use three-fifths of the total study time for hands-on activities or learning by doing. Technology studies must continue from primary school to secondary school without any gaps in the coverage of topics.

The Technology Education Curriculum of the Netherlands

The Technology Action Plan for The Netherlands was implemented during the years 1993 to 1997 for primary schools (pupils aged 4 to 12). Financed jointly by the Ministries of Education, Culture and Science, and Economic Affairs, the purpose was to stimulate attention to technology within and outside primary schools. Importance is given to combining thinking with doing (Lemmen 1997, p. 118).

In the Netherlands, all pupils go to the comprehensive school, "Basisvorming," until the age of 15 or 16. After national debates of what the content of basic education should be, the present curriculum was published in 1998. There are at least 15 subject areas to be studied, with one of them being

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technology. There are five general objectives to be achieved within all the subject areas:

- working on interdisciplinary themes
- learning to carry out a plan and task
- learning to learn
- learning to communicate
- learning to reflect on the learning process and the future

Technology is studied from three different perspectives:

- technology and society
- technical products and systems
- designing and making products

Rationale and Content

The overall purpose of the technology education curriculum is to enable the students to:

- become familiar with those aspects of technology that are significant to an understanding of culture, to the way in which pupils function in society, and to the development of pupils' technical abilities
- acquire knowledge and understanding of the function of technology and its close relationship with natural sciences and society
- become actively involved in applications of technology
- learn to design and develop solutions for human needs
- learn how to use a number of technological products in a safe manner
- be given the opportunity to explore their abilities and interests in technology

The specific objectives are organized under the headings of technology and society, technical products and systems, and the design and making of products.

Implementation Goals

Technology education curriculum should offer equal opportunities and appeal to both boys and girls (Huijs 1997, p. 107). At the primary level it is not a separate subject area, but is integrated with crafts, arts, and natural sciences. At the secondary level it is a subject area of its own, but it is also integrated with mathematics, science, and social studies. In the first and second years of secondary technology, it is studied for two teaching hours per week. At the secondary level, 180 teaching hours are allocated to technology education.

Other Observations

National tests are given upon completion of the secondary school program.

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The Technology Education Curriculum of Sweden

In Sweden, the equivalent to technology education is called "teknik" (technics). According to the national curriculum of 1994, technology education aims to develop in pupils an understanding of the essence of technics, particularly, an understanding of the impact of technology on production, society, physical environment, and living conditions. Technical expertise becomes an important prerequisite for the control and use of technology.

Pupils are expected to achieve basic technical competence (grundläggande teknisk kompetens). This competence results from gaining knowledge of the role of technical development, historical perspective, and reflection on the solution of technical problems. In addition, there is need to develop an ability to analyze and value the relationships among human beings teamwork in the context of society, technics, and nature. Students are to understand the way technics is used and its effects on the environment. A number of ethical questions dealing with basic values are also addressed.

Rationale and Content

The primary objectives of the study of technology education in Sweden are to:

- study the history and development of technical culture, and the effects of technics on people, society, and nature
- develop an awareness of the technics in the world around the student
- reflect upon and evaluate the effects of choices of different technics on human beings, society, and nature
- update technical knowledge of the structure and use of technics for practical situations
- have a positive interest in technics and confidence in their own abilities to solve technical problems

The objectives to be achieved are stated in such a way that they describe what pupils should have learned by the end of grades five and nine. Meeting these objectives provides a basis for making choices about careers and further education.

The primary teaching methods emphasize practical work and exploration. Students are to be engaged in doing tests and observing results, planning, constructing, and evaluation.

Implementation Goals

Technics is to be studied at both the primary and junior secondary levels. It should be integrated with history, science, and social studies, and offered equally to girls and boys. The study of technics:

- should promote development of perspective regarding the effects of technics on individuals, society, and nature from a historical and international point of view

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- should illustrate interaction among humans, technics, and nature
- should convey that the purpose of technics is to alter, store, and control
- should present a component – system point of view
- should include construction experiences in a workshop environment for the identification and solution of problems

Other Observations

The curriculum documents indicate a belief that the technical culture is mainly based on the tradition of know-how that has been achieved through practical work. Current technological development is based more on scientific research and systematic development than has been true in the past and this should be reflected in the school curriculum.

The Technology Education Curriculum of the United States

In the United States, there are national standards for various core subjects. At the time of the study, standards existed for English, language arts, geography, music, art, social studies, foreign languages, mathematics (curriculum and evaluation standards were approved as early as 1989), and science (national standards were approved in 1996). The most recent subject for which standards were developed is technology education. They were approved at the beginning of the year 2000. The Technology for All Americans Project has been engaged for the past several years in research and development for technology education. In 1996, an initial statement and policy document called *Technology for All Americans: A Rationale and Structure for the Study of Technology* was published. This publication provided the basis for technology education in the United States and became the philosophical foundation for the *Standards for Technological Literacy: Content for the Study of Technology* (ITEA. 2000). These two documents are intended for state and local curriculum planning.

Rationale and Content

The principal rationale for technology education in the United States is that every citizen should be technologically literate and, thereby, is able to use, manage, and understand technology. Technology is defined as human innovation in action. The framework for technology education is based on the universals of technology. These universals are considered to be significant and timeless, even in an era dominated by uncertainty and accelerated change. At the time this study was started, the universals were comprised of knowledge, processes, and contexts. Though these universals changed with the release of the final version of the Standards (ITEA, 2000), they nonetheless represent the initial philosophy.

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Implementation Goals

- technology should be integrated as one of the core subjects from kindergarten to junior and senior high schools, and even beyond
- technology education can be integrated with other school subjects, especially with science and mathematics
- technology should be compulsory at every study level, for girls as well as boys
- local conditions, aspirations of individuals, career goals, and abilities should influence the development of the curriculum for technological literacy
- the ultimate goal is to realize technological literacy for all

Other Observations

The *Standards for Technological Literacy* underwent an extensive review and consensus-building process that extended over a lengthy period of time. The National Academy of Engineers and the National Research Council, very influential and important organizations, were closely involved in the development of the Standards.

Summary of the Curricula of the Selected Countries

The curriculum documents of the six countries vary significantly. On the one hand are *lehrplan-type* documents (from the German word for curriculum) that provide very specific details of what should be taught and how it should be taught (used in Australia and England). On the other hand are curriculum *standards-type* documents that specify the goals that should be met, but do not specify the actual curriculum (used in Sweden and the United States). Standards-type documents are more general and allow a great deal of flexibility (see Malinen, 1985, pp. 17-19 and 39-45). France and the Netherlands use guidelines that are combinations of the two types, having a standards-type emphasis but with many lehrplan-type components (see e.g. Malinen 1992, p. 15). All of the documents described above were published relatively recently. The curriculum documents of Australia and Sweden are the oldest, dating back to 1994. The curriculum for lower-level classes in France is from 1995 and the curriculum for upper-level classes from 1997. The attainment targets of the Netherlands were revised in 1998 and 1999 (see also deVries 1999, p. 143). In England, the curriculum was revised in the year 2000. The curriculum standards for technology education in the United States were published most recently (2000).

According to the technology education curricula of the six countries studied, technology should be studied by both girls and boys. In all of the curricula the importance of studying the effects of technology on society are emphasized, and Sweden particularly emphasizes the importance of the history of technology. France is the only country that does not directly refer to studies of the relationship between technology and the environment. In all the countries, learning how to plan, produce, and evaluate is emphasized. The ability to

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tolerate uncertainty is included in the curricula of Australia and the United States. In the Australian curriculum the importance of life-long learning and learning of innovative skills is clearly a focus.

Systematic Analysis

To analyze the curricula of the six countries in more depth, a special method called *systematic analysis* was chosen. In this method, factors connected to a particular theory or idea are clarified. In other words, a single method is not used alone, but rather a "method-family" is usually identified and applied (Scriven 1988, pp. 131 - 149; Jussila, Montonen & Nurmi 1992, p. 157). This method includes a qualitative analysis of the content of selected excerpts of text. In this study, the objects of the analysis were the technology education curricula of the six countries.

Systematic analysis differs from content analysis in that the goal is to penetrate the world of ideas as they are expressed linguistically. The aim is not to search for and present statistically representative samples, but to bring forward the essential ideas from thinking-structures in order to make possible the clarification of the original thought entities and their further development if needed (Jussila et al. 1992, p. 160, see also Alasuutari 1993; Pyörälä 1995).

In systematic analysis, logical and conceptual entities are highlighted through theoretically oriented exploration. The task of the researcher is to look for fundamental questions from within the content of the text and to outline and examine the text in order to discover core ideas, even those that are not obvious. A mere description of the expressions presented is not sufficient in this type of analysis (Jussila et al. 1992, p. 174).

One of the objectives of this research was to look for suitable components for the Finnish curriculum framework so that they could be applied by municipalities and individual schools. A two-dimensional model was thus developed to meet this objective. One dimension was the influencers of curriculum and consisted of three elements, the society, the school, and the individual.

- Society (global, state, municipality)
  Elements include technology as part of society, technology and the environment, the relationship between industry and school, the needs of society and people, and technological professions.
- School (teacher)
  Elements include the interaction between the school and the environment, technological know-how, the learning environment, and integration among different subject areas.
- Individual (student)
  Elements include technological literacy, the interaction between technology and the individual, environmental balance, ethics of technology, technological skills and knowledge, and interest.

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The second dimension was the internal elements of the curriculum: objectives, methods, and content. Figure 1 below describes the analysis framework.

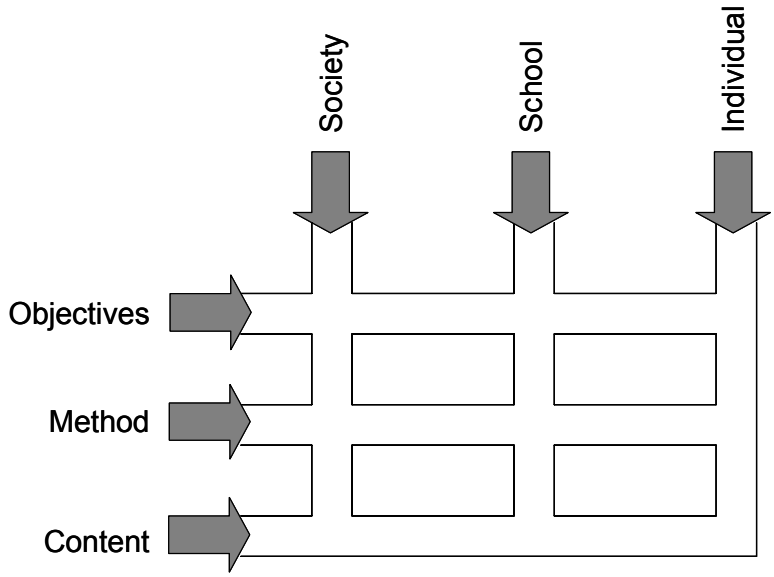

Figure 1. The dimensions of analysis.

Results of the Analysis

The elements of the results of the systematic analysis are presented in abbreviated form in Table 1. The information presented in the table is not in any particular order of importance. For the complete results of the study, the reader is referred to Rasinen (2000).

Although the format and approach in the six curricula studied differ from one another in many ways, common features were found. There were no particular contradictions among any elements of the six curricula, nor are there significant differences in the emphasis placed on the various sub-areas of technological studies. The French curriculum appears to give more attention to computing as a principal focus, whereas computers are seen more as one of the tools of technology in the other countries.

As Table 1 illustrates, there are many overlapping elements, regardless of whether the table is studied horizontally or vertically. Technology is universally seen as a significant part of human life; it affects the routines of individuals, schools, and the whole society, from local municipalities to the entire world. It is considered important to realize the history and development of technology and its effects on human beings and the environment. Technology is not seen as something good that has to be accepted as it is, nor is it seen as something bad,

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which therefore has to be denied or ignored. Technology is around us, whether we want it or not. Thus, students should be educated to cope and deal with

Table 1.
Comparison of objectives, methods and contents by the perspectives of society, school and the student.

	OBJECTIVES	METHODS	CONTENT
SOCIETY	Technology is an integral part of society Human needs and technology are intimately connected There is a need to establish a balance between technology and nature There are careers in technology and the schools should provide practical, exploratory experiences related to them	Increase cooperation between the schools and the community outside the schools Provide experiences that prepare the student for life after school Experiences should include teamwork, analysis, invention, planning, producing, and evaluating Experiences should be provided that promote positive attitudes toward careers in technology Experiences should be provided for all students to increase tolerance for uncertainty For boys and girls	Systems and structures of technology (mechanisms, structures, products and their applications, transfer, storage, control, regulation, processing, communication, information, energy, power, quality) Careers in technology (production process, working conditions, control of quality, sharing of work, technical appliances used by different professions, changes in different professions) Safety and ergonomics
SCHOOL	Role of technology in society Skill development (planning, making, knowing and understanding, evaluation, social interaction, moral and ethical) Integration with other subjects	Integration into/with other subjects Experiences in planning Learning by doing Teacher education and in-service development are critical National examinations in technology are needed	Planning, making, evaluating Information Materials Systems Control of systems Structures Processing Communication Energy and power Safety

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Table 1.(continued)
Comparison of objectives, methods and contents by the perspectives of society, school and the student.

	OBJECTIVES	METHODS	CONTENT
STUDENT	Technological literacy (ability to use, control, and understand technology) Problem solving skills Understanding the role of science and technology in society Developing technology in balance with the environment Moral, ethic, and social justice Know-how, skills, values Adopting critical attitude Applications of technology Planning and solutions from human viewpoint Students should become more innovative, conscious, skillful, flexible, and enterprising	Planning, co-operation and networking. Practical work: experiments, observations and building; planning and evaluating. Learning by doing Safety	Role of technological development History of technology Solving technological problems Evaluation and valuation of the relationship between humans, society, and nature Effects of technology on nature Functions of technology (alter, store, control, and regulate) Process work (identifying, constructing, and evaluating) Information Energy and power Materials Safety Marketing

technology, to develop it in balance with the environment, and to approach its study with a realistic, yet critical, manner. None of the technology education curricula included in the study defined directly any philosophical points of departure. They do, however, offer brief statements on the importance of the study of technology. The rationale the countries share in common is the need to prepare students to live in a rapidly changing technological world. There seems to be a universal emphasis on learning to plan and produce solutions to technological problems, to become discriminating and informed users of technology, and to become innovative thinkers. Understanding underlying social, aesthetic, and environmental issues is also considered essential within all six curricula. The importance of learning by doing and problem solving is universally evident.

The educational approach to the curricula is clearly hermeneutic. The objective is to learn about natural world and how humans have changed it

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through technological development. Humans are regarded as goal-oriented, intentional, and active beings who form social systems. Students must learn how to make rational and justified choices while they are in school so that they become contributing members of society once initial schooling is complete.

Technological phenomena are studied as phenomena in themselves. That is, their essence and nature are considered but little attention seems to be placed on what influences them. For example, it is universally believed that students should learn planning, making, and evaluating. However, the way in which the brain controls the planning process or what factors affect eye-hand coordination are not included.

Discussion

The six countries chosen to be studied in this research are at different stages of developing their technology education programs. Departure points for curriculum planning, the planning process, and the structure of the curriculum differ from one country to another. For these reasons, a single model cannot be applied to each country. The curricula have, however, been observed from so many different perspectives that the essentials have undoubtedly been discovered. Although the countries under study are separated geographically at quite a distance from one another and their cultures also differ, there are several similar features in their curricular objectives, methods, and content.

Technological literacy is a universal goal. Principal objectives include understanding the role of science and technology in society, the balance between technology and the environment, the development of technological literacy, and the development of skills such as planning, making, evaluating, social/moral/ethical thinking, innovativeness, awareness, flexibility, and entrepreneurship. The prominent methods focus on experiences for students that engage them in planning, analyzing, inventing, innovating, making, and evaluating. The most significant content includes the systems and structures of technology, professions in technology and industry, safety practices, ergonomics, design, construction techniques, assessment practices, the role and history of technological development, problem-solving strategies, and evaluating and valuing the relationship between society and nature. The list of content included in the curricula of the six countries was quite broad and extensive, making it very difficult to condense it. The long standing argument of breadth versus depth was clearly evident across all of the curricula, with the former being more prevalent than the latter.

The way in which technology studies have been organized also differs from country to country. For the most part, technology education at the primary level is integrated with other subjects, such as handicrafts and science. Since technology education at that level is mainly taught by class teachers, it is more natural and easy to integrate it with other subjects than would be the case if the subject were taught by subject specialists. However, in England, where the practice is already several years old, technology education at the primary level is

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taught as a separate subject. A systematic in-service program assists the teachers in updating their knowledge and skills.

Technology education in the junior and senior secondary schools in the countries studied is usually taught by specialized subject teachers. However, integration among different subjects and the surrounding society seems to be emphasized universally, at least in theory.

Since technology education does not have a long tradition, the standards of teaching vary widely. The extent to which technology education has evolved varies from one country to another, ranging from the highly developed programs in England to those less developed in other countries. Though technology education in the US has existed for a number of years, there are still few programs at the elementary level. Among the countries studied, technology education is developed to the greatest extent at the middle school/junior high (lower secondary) levels. Even at this level, though, there are still many obstacles that must be overcome before the intended curriculum can fully realize its intended goals and ideals.

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