A Proposal for Science Education Policies in Lebanon Based on Trends in Selected Developed Countries Over the Last Twenty Years.

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Abstract

The present study examines science education policies in three selected developed countries and compares them with science education policies in Lebanon in order to identify their potential reform policies and practices applicable to Lebanon. The selection of the three countries, the U.S.A., U.K., and Japan, was based on the amount of time and effort devoted in these countries to improving and modernizing their science education policies and curricula. Three aspects of secondary science curriculum policy in the chosen countries were analyzed and compared with those of Lebanon. These were: aims and objectives; pattern of science program including the science curriculum, the amount of time allotted to the study of science and the content of school science subjects; and the organization of school science including science requirement for graduation from high school, teaching strategies and mode of examinations. The data collected for analysis from the three chosen countries showed that, unlike Lebanon, in the three developed countries: education is compulsory up to at least the age of 16; aims and objectives are stated clearly and carefully; science is an integrated subject in the first year of secondary level, then it becomes separated into chemistry, physics and biology. The content of science subjects emphasizes the method and process of science and its application to the society. Examinations are designed to evaluate students' learning in science in contrast to Lebanon where examinations are designed to discriminate among students.

Résumé

Cette étude scrute les politiques de l'enseignement des sciences de trois pays parmi les plus industrialisés et les compare à la politique en vigueur au Liban. Nous ferons ressortir les principales reformes entreprises dans ces pays et leurs possibles applications au Liban. Le choix de ces trois pays, les États-Unis, La Grande -Bretagne et le Japon, se justifie par l'immense effort et le temps investis par ceux-ci depuis quelques années pour améliorer et moderniser l'enseignement des sciences. Pour chaque pays, nous avons analysé trois aspects du curriculum en sciences au niveau secondaire et les avons comparés avec ceux du Liban. Nous avons retenu: les buts et les objectifs, Le profil de formation en science incluant le curriculum, le temps alloué à l'enseignement et le contenu des différentes matières scolaires et, finalement, l'organisation des sciences à l'école y compris les exigences pour l'obtention du diplôme du secondaire, les stratégies d'enseignement ainsi que le mode d'examens. Les données obtenues pour analyse de ces pays démontrent que, à la difference du Liban, l'éducation y est obligatoire au moins jusqu'à l'âge de 16 ans; les buts et objectifs y sont affirmés soigneusement et explicitement; la science est une matière intégrée aux autres matières scolaires dès la première année du secondaire et se subdivise en cours de chimie, de physique et de biologie dans les années subséquentes. Le contenu des programmes insiste sur la méthode et le processus scientifiques ainsi que sur leurs applications concrètes dans la société. Les examens sont conçus pour évaluer la connaissance scientifique des étudiants, contrairement au Liban où ils y sont élaborés pour selectionner l'élite estudiantine.

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Chapter 1 Introduction

The Problem: The Need for Science Curriculum Policy Improvement in Lebanon

Most of the research in science education in Lebanon was done in the late 70s and early 80s. Due to the war situation in Lebanon (from 1975 to 1992), with few exceptions, most materials which deal with school curricula are 20 years old. National studies of science curriculum policies in Lebanon have identified certain specific difficulties afflicting science education (Badro & Kraidy, 1980; El-Amine, 1994). These difficulties were also identified by opinion surveys of teachers, laymen, parents, and principals (The Center for Educational Research and Development, 1974). The objectives, aims and purposes of science curriculum were found to be no longer relevant to the needs of the student in today's society (Boujaoude, 1996; Boujaoude & Khalid, 1995; Zouain, 1994). These conditions are compounded by a shortage of qualified science teachers (Zouain, 1994). Science teaching and learning in Lebanon are now lagging behind contemporary international trends. This study will propose a relevant science curriculum based on an analysis of the science curriculum policies in three developed countries.

Teaching of science is considered to be an integral part of general education (American Association for the Advancement of Science, 1989a, 1989b). Basic scientific knowledge is recognized as being necessary and important for the population as a whole. In general, science education should adapt to the society within which it is practiced. This includes taking into account the needs of students as well as changes in the social, economic, and political environment.

In order to bring innovation to science curriculum policies in the Arab States which include Lebanon, the education leaders of all Arab States met in Abou Dhabi (1977) and recommended that:

> Education [in all Arab countries including Lebanon] should be designed in order to keep pace with educational trends. (UNESCO, 1977, p. 23)

The conference stressed that educational innovation in science curricula in Arab countries (teaching methods, textbooks, teaching aids) should make use of contemporary world experiments and experiences. This did not happen in Lebanon because of the war which lasted seventeen years (1975-1992).

Science education is now an area of pressing concern expressed in National reports (El-Amine, 1994; Zouain, 1994). The science curriculum is no longer adequate and does not meet the needs of students in a changing society. Furthermore, school science content is out of date and far behind contemporary knowledge (El-Amine, 1994). This concern is heightened by the sense that students today and tomorrow will need a very different, more extensive science education than secondary schools have provided in the past (El Amine, 1994; Zouain, 1994). Proposals for a new science curriculum for

Lebanon that incorporate recent research and experiences in other countries are therefore timely and appropriate. With an appropriate school science curriculum that takes into account the needs and interest of students, as well as the needs of society, students will be better prepared to function effectively in tomorrow's society.

Research Questions

This study looks at science education policies in selected developed countries and compares them with science education policies in Lebanon in order to identify their implications for reform policies and practices applicable to Lebanon. It will answer the question: "What aspects of science curricula from U.K., U.S.A., and Japan would be appropriate for inclusion in a science curriculum for Lebanon?".

The aspects of science curricula considered will be: a) the aims and objectives; b) the pattern of science programs, which is defined as the science curriculum, the amount of time allotted to the study of science and the content of school science; and c) the organization of school science, which is defined as science requirements for graduation from high school, teaching strategies, and mode of examinations.

Scope of the Study

Five practical limits to the scope of the study are considered. These are: definition of "science" subjects; the countries chosen; theoretical approach to science teaching and learning; the school educational level; and the curriculum guidelines.

Definition of "science" subjects

In this study, the basic science subjects are defined as biology, physics, chemistry with the addition of the National Science Education Standards list: physical science, life science, earth/space science, science and technology, science in personal and social perspectives (STS), and the history and nature of science (National Research Council, 1996). Social studies, mathematics, technology (in the sense of design or craft) and computer studies will be excluded from this study, even if in some countries they are considered to be science subjects. Technology is treated in this study when it is included in a science course as an application of science. The New Information Communication Technologies (NICT) are recognized as essential teaching tools, rather than as curriculum content.

Countries chosen

An overview of science curriculum policies designed for general students will be undertaken and a more detailed examination and analysis of science curriculum policies developed for advanced students in science will be conducted for the U.S.A., U.K., and Japan for comparison with those in Lebanon. These countries were selected for the following reasons:

1. A review of the literature shows that these countries have devoted large amounts of time, money, and effort to improve and modernize their science education policies and facilities.

2. These countries are well-known for their contemporary policies in science education and for the scientists trained as a result of applying these policies.

3. Recent reforms in science curriculum policies in these countries, mostly developed since the mid 1980s, reflect the rapid changes in individual and societal needs.

4. The three countries are generally successful in international assessments of achievement in science [e.g. Third International Mathematics and Science Study (TIMSS), 1997] (Science Education Newsletter 134, 1997).

Although the current science curriculum in Lebanon is a version of the previous one, which was based on the French system, France is not included in this study. This is due to the fact that reform is currently taking place in France in order to make the educational system in that country more effective and challenging. To accomplish this, the French are looking at the experience of the countries selected in this study (Hasegawa, 1993; Les systèmes de formation, 1993).

Theoretical approach to science teaching and learning

Decisions regarding curriculum are based on theoretical considerations. The study will outline some of the major curriculum theories that have informed curriculum decisions in countries described in this study, although the extensive literature dealing with the psychological foundations on which these decisions have been based is outside the scope of this study.

<u>Educational levels</u>

Science forms a part of the curriculum of almost every school in Lebanon. Students are required to study this subject from their earliest years in the classroom until at least the end of high school level. This research is primarily concerned with science education at both lower and upper secondary school levels. The lower secondary school level in this study is defined as grades 7, 8, and 9 where the age of students varies from 12 to 14. The upper secondary school level are grades 10, 11, and 12 where the age of students varies from 15 - 17 or 18. The objective of this research study is to analyze science curriculum policies and curriculum resources in lower and upper secondary school levels and to propose a curriculum for Lebanon based on this analysis for the following reasons:

1. Reform of science curriculum policies at the elementary level in Lebanon has taken place more recently than at the secondary level. The elementary school curricula have been revised and textbooks and teacher guides have been prepared (Za'rour, 1983). However, science curriculum policies at lower and upper secondary levels have not been subject to any practical reform since 1970 (for lower secondary level) and 1968 (for upper secondary level (Zouain, 1994). There is no evidence that any government

document on science curriculum at the secondary level has been published since 1975.

2. A study of science curriculum policies in Lebanon carried out by the Ford Foundation (Maybury, 1975), by the Lebanese Center for Educational Research and Development (CERD) (Bashour, 1979), and by UNESCO (1991a) showed a need to change the way science was taught at both lower and upper secondary levels. Although all these studies found that the aims, purposes, and objectives of science were no longer relevant to the needs of the student, in practice, nothing has been done in Lebanon to improve secondary science curricula in order to help the student to function effectively in today's society.

3. In the upper secondary level in Lebanon, science is a compulsory subject for all students At the end of this level students sit the National Secondary Examination, the Lebanese Baccalaureate. It has been demonstrated that the type of questions contained in the examination are in some cases irrelevant to the objectives and contents of science courses studied (Eid, Kassab, Sarkis, & Zraiby, 1979): most questions were in the knowledge category as defined by Bloom (1956) and later specified by Klopfer (1971). This discontinuity between secondary school science programs and examination questions identifies another problem which contributes to the importance of this study. There is no evidence that examinations have improved since 1979.

4. In Lebanon, many students do not go beyond the Baccalaureate II (Grade 12 in Canada). The percentage of students who actually attain

university level is small (Abou Roujaily, 1984; Badro et al, 1980; Zouain, 1994). Therefore, if students are to learn science, this learning will take place at the secondary level. These students are called general students in this study. For students planning to continue their science studies there is a need for substantial content and enriched programs. These students are called advanced students in this study.

5. At both lower and upper secondary school levels, the numerous and broad objectives of science correspond to the much broader range of students. At these levels, school curricula should address the needs of all students, and science programs must serve a wide variety of purposes. By contrast, at university levels where students intend to specialize in scientific work for a career, programs and objectives are relatively few and more specific. The wider range of students and objectives at both secondary levels will provide more comparisons to be examined in this research.

Thus, this study will concentrate on lower and upper secondary levels where it will be shown that the nature and quality of science teaching and learning and the examinations need improvement.

Limitations for the study

This study is limited to an examination and analysis of science curriculum policies (including rules, syllabi, plans and guides) because they are readily available and open to comparison. It does not examine the various conceptualizations of curriculum, nor the variety of ideological frameworks of which curriculum developments are based. Rather, it assumes that the three countries selected for analysis have all based their science curricula on similar positivist models. Other problems identified by the CERD (1974) and by El-Amine (1994) such as poorly described curriculum guides, lack of adequate teaching materials and practical work are beyond the scope of this study. The literature examined for this study will include primary sources from each of the four countries as well as supporting evidence from summaries and secondary sources where appropriate, or where primary sources are missing. It will be apparent that the war has caused many gaps in the Lebanese sources.

The present study therefore compares secondary science curriculum policies in the U.S.A., U.K., and Japan with policies in Lebanon and proposes new directions for educational reform in the Lebanese science curricula. Some of the government documents from Lebanon may appear to be outdated. But since curriculum reform in Lebanon has been stagnant since the war, it is appropriate to review the literature on science education policy trends since the mid 1970s. This will show the developments that have occurred in the chosen countries as a background to the present situation.

Outline of the Study

The remainder of study is organized into five chapters:

Chapter 2 deals with international trends in secondary science curriculum policies. It reviews the theoretical reform undertaken by certain educational and scientific organizations and associations in the countries included in this study.

Chapter 3 reviews the general, historical, cultural, political and economic context of Lebanon and its educational system.

Chapter 4 reviews science curriculum policies in the selected developed countries planned for general students. It also provides a comparison of science curriculum policies designed for advanced students in science in the selected developed countries.

Chapter 5 looks at science curriculum policies in Lebanon and compares them with similar policies in the selected developed countries. It also identifies major problems and needs drawn from this analysis.

Chapter 6 presents some recommendations for the development of a science curriculum in Lebanon.

Chapter 2 International Trends in Science Curriculum Policies

Science is a basic and important aspect of everyone's intellectual development. The end product of science education continuously influences our way of life: our health, our modern conveniences, and the basis of our economy. In a growing number of countries, the 20th Century has come to be known as the age of science. It has been an era of constant change which has become an element of educational policy (Lee, 1991). A review of the literature shows that most developed countries have reexamined, revised, and restated their aims in science education over the last twenty years. The content and the teaching methods have also been subject to similar scrutiny. Syllabi are becoming more practical in character and are based on the criterion of their validity as preparation for life and for further study. All students must be provided with science experiences that will assure them of developing concepts, attitudes, and skills which will, in turn, enable them to live and function effectively in an ever changing scientific and technological society.

This review examines theoretical reform projects to improve science curriculum policies put forth by certain educational and scientific organizations, and formulated by the countries included in this study.

Science Curriculum Policy Reform: UNESCO and Other Organizations

Work done by UNESCO in the late 1970s and early 1980s, has formed the basis of much of the science education policy in other countries. It is therefore worthy of detailed consideration.

A review of UNESCO work on science curriculum policies shows that the trends in science education throughout the world are toward a recognition of the interdisciplinary nature of science, a view of science as an entity as well as a collection of separate disciplines. At the school level today, biology, physics, and chemistry are not taught in isolation. The links between the disciplines have blurred their boundaries (UNESCO, 1980, 1990a). This interdisciplinary approach to science is known today as "integrated science". Two key UNESCO studies in integrated science were published in 1979 and 1990. Both will be addressed in this section.

The concept of integrated science

"Integrated science" has been defined as, "those approaches in which the concepts and principles of science are presented so as to express the fundamental unity of scientific thought and to avoid premature or undue stress on the distinctions between the various scientific fields" (UNESCO, 1983a, p. 115). This definition encourages a broad diversity in the overall structure and organization of programs that are considered to be integrated science (Chisman, 1990).

Integration can be between two or more natural sciences such as chemistry, physics, biology, astronomy, earth science and environmental science, or among basic and applied sciences and technology or between science and non-science disciplines. In this study, integrated science will be limited to those areas involving natural sciences and in some cases their related technological topics. In many countries science courses at the primary level are well-integrated. However, at the secondary school level where various natural sciences are taught, "integrated science" is a relatively new phenomenon.

A review of recent studies on science curriculum has shown that the field of integrated science education has expanded rapidly in the last few decades. According to UNESCO (Haggis & Adey, 1979), there were more than 130 courses in integrated science worldwide, most of them at the lower secondary level where the pupil's day-to-day experience is often treated in an integrated manner. Today integrated science constitutes an important part of any science curriculum policy. It contributes to general education, emphasizes the fundamental units of science and leads towards an understanding of the place of science in contemporary society. It avoids unnecessary repetition and permits the introduction of intermediate disciplines such as economic, social, and environmental issues (Chisman, 1990). Integrated science is used to provide the framework within which science can be taught in a relevant way. Relevant science, as defined by Maybury, is a subject that has a broad set of objectives necessary to allow all students, regardless of their abilities, to satisfy their needs (Maybury, 1975). The following pages will explore some projects developed by UNESCO and other organizations. These projects could be useful in revising the secondary school science curriculum in Lebanon.

In New Trends in Integrated Science Teaching (volumes V and VI) UNESCO (Gadsden, Betch & Dawson, 1979; UNESCO, 1990a) surveyed over 100 integrated science projects; twenty-three different kinds of objectives were identified and classified in five categories. These are:

1. Scientific literacy that includes objectives dealing with the processes, nature and values of science; science and society; manipulative skills; and attitudes toward science.

2. Personal growth that deals with the view of self; intellectual abilities; and enrichment of life.

3. Social relevance that includes comprehension and solution of problems; practical knowledge; and attitudes toward school and society.

4. Immediate, personal concerns that include preparation for examinations and higher education; career awareness and preparation; and survival.

5. General education that deals with man's effects on culture and nature.

The information above shows that the major trend in integrated science was the total education of the learner, including the development of social and manipulative skills and intellectual abilities. Integrated science also emphasizes scientific literacy, more numerous and broader objectives, increasing relevance, tying science more closely to society, and an awareness of career opportunities in the field of science and applications of science into the world of work. Examination of the UNESCO study on integrated science also shows a trend away from discipline-centered science and toward inclusion of programs in environmental education, health and nutrition, the interaction of science and society and science-integrated technology.

Each of these topics or programs that could be considered appropriate to Lebanon will now be explored separately.

Integrated science and environmental education

The environment can be viewed as a laboratory which, unlike traditional science laboratories in chemistry, biology and physics which require space and expensive materials, provides us with valuable and inexpensive resources in the form of a school garden, a zoo, a farm, a factory, a mining site, and other natural locations. The environment can be considered as an excellent integrating theme providing relevance and a social focus to science.

In 1975, UNESCO and the United Nations Environment Program (UNEP) jointly launched the International Program for Environmental Education (IPEE) (Connect, 1985). The main tasks of the IPEE were to establish pilot projects, and elaborate policies and strategies of environmental education at all levels: local, national, regional, and global. UNESCO defines

IPEE as any intentional endeavor to help individuals and students to learn something in some setting about the environment, the dynamic reciprocal interaction of man with it, and the need for and ways of affecting this interaction process (UNESCO, 1978). As a result of the various activities of the IPEE, more than 40 countries have officially introduced environmental education into their science educational policies and reform (Connect, 1985).

According to UNESCO (Connect, 1985; UNESCO, 1990a) almost all school science curricula at secondary school level contained environmental topics, environmental education objectives and content. What was lacking most often was a more systematic development and integration of the environmental component into science curricula (Connect, 1985; UNESCO, 1990a). It was suggested by the IPEE that at the senior secondary school level (the terminal level for many students) further attention could be focused on the environment through an interdisciplinary environment course involving chemistry, physics, biology, geology and other disciplines.

The Intergovernmental Conference on Environmental Education (1978) held in Tbilisi in 1977 proposed a course in environmental education based on the outcomes of the previous conferences held respectively in Stockholm (1972) and Belgrade (1975). The principal audience in the formal education sector for whom this course was designed is secondary school teachers and students. It was also suggested that environmental education be incorporated into programs intended for learners at all levels (Haggis, et al, 1979; UNESCO, 1990a).

The goals of the environmental education program designed at the Tbilisi Conference (UNESCO, 1978) were to develop a population with a clear awareness of the environment and its related problems, and to provide students with the knowledge, skills, motivation, attitudes, and commitment to work individually, or in groups, toward solutions of current problems and the prevention of new ones. The goals have been translated into six categories of objectives. These are: a) awareness; b) knowledge; c) attitude; d) skills; e) evaluation ability; and f) participation (UNESCO, 1978; Dyasi, 1979).

A working group at this conference proposed that environmental education should a) center on specific interdisciplinary problems, b) emphasize a "learning by doing" approach, based on diversity of experience and direct contact with the local environment, and finally stress the active participation of individuals and groups at all level in working towards resolution of environmental problems (UNESCO, 1978). The group also recognized the need to introduce an environmental dimension into all disciplines and educational curricula. It should be centered on practical problems and be interdisciplinary in character (UNESCO, 1983a). In short, environmental education should aim at providing knowledge which is scientifically based, and develop attitudes and values which form the solution to environmental problems.

The participants at the International Congress on Science and Technology Education and National Development held in Paris in 1981 (UNESCO, 1981) took the view that humanity should direct its efforts toward improving quality of life, preservation of the environment, and intelligent exploitation, processing and utilization of its resources. In order to reach this goal, schools should provide students with knowledge and the understanding of the ways which may be used to support the self-regenerative capacity of nature and prevent undesirable practice. The trend today in teaching integrated science programs is toward the inclusion of environmental issues which have an international dimension such as population, energy, pollution, agriculture, water, and air. These issues attempt to relate teaching to social concerns (Chisman, 1990).

Integrated science and technology

The International Symposium on the Teaching of Science and Technology in the Context of General Education (UNESCO, 1985a, 1985b) involved a study of one hundred definitions of technology. The following definition was suggested for consideration (Vohra, 1987):

> Technology is the know-how and creative process that may utilize tools, resources and systems to solve problems, to enhance control over the natural and man-made environment in an endeavor to improve the human condition. (p.415)

The concept of "technology", no longer limited only to technical and vocational education, now reflects ideas and characteristics such as creativity, curiosity, design, skill, problem solving, use of resources, improvement of the human condition and control of the environment, both natural and man-made. Technology and science studied in school are related through mutual influence and resources. Science influences and is influenced by technology. Equally science provides resources for technology and is provided with resources by technology. It has also been pointed out that science and technology result both from the application of scientific knowledge to practical purposes and from a response to practical problems (Edwards, 1987).

Today modern technology is considered to be a part of modern society. The integration of technological topics into secondary school science could increase students' motivation, attitudes and creativity, and help them to link their school activities with the world around them. Technology has always occupied an important place in UNESCO's programs. Science and technology were included in 3 of the 14 major programs in UNESCO's medium-term plan for 1984-1989 (Samady, 1984). It is widely recognized today that science and technology form an integral part of contemporary culture. Their application contributes to improving our living standards and conditions. Efforts have been made in most countries to integrate technological topics within interdisciplinary science courses, and to develop the teaching of science and technology at all levels of secondary education. In Interest in Science and Technology Education: 12th Symposium (UNESCO, 1984), six main arguments were used to justify incorporating technology into secondary school science curriculum:

1. Science and its applications in technology can help to improve the quality of life.

2. It is important that future citizens should be equipped to live in a world which is scientifically and technologically oriented.

3. In many countries secondary schooling is terminal for many children; therefore it may become the only opportunity for them to explore the environment in a logical and systematic way.

4. Science and technology can help students to acquire intellectual skills which will be valuable for them wherever they live and whatever work they do.

5. For effective science education, science teaching should stress scientific and technological knowledge. It should take the object of its study from the surrounding environment and adapt its explanation to rational ideas that exist locally.

6. Teaching of technology constitutes that part of the teaching of science concerned with the use of scientific knowledge, principles and skills for practical application in the various branches of industry, agriculture, medicine, and land use. Taking account of the dependency of human life on these necessary skills, technology becomes inseparable from science curriculum.

The above six main reasons apply to Lebanon and suggest that at the secondary school level, education through science-integrated technology should continue to make a major contribution to general education regardless of whether or not the pupil proceeds to a scientifically or technologically oriented career.

According to a number of UNESCO publications (UNESCO, 1986a, 1986b, 1988, 1990b, 1992), many science and technology courses have been developed in recent years. The stated aims and objectives of these integrated projects are:

1. To open a window onto the world outside the school laboratory and to link science with technology so that the student will view the nature of science as a human enterprise.

2. To teach students scientific concepts and ideas that are relevant to real life and which will motivate and encourage them to study science.

3. To help students: a) acquire knowledge and understanding of scientific and technological issues; b) understand that science and technology are sources of change in society; c) acquire basic knowledge and skills; d) apply the knowledge, skills and processes to their everyday life; e) appreciate that scientific theories are tentative and subject to change in the light of new evidence. These changes can affect technology and society; and f) to acquire a range of cognitive and psychomotor skills and processes from the personal experience of scientific activities, procedures and applications in the laboratory and in the field.

4. The attainment of a scientific perspective gives one way of looking at the world, together with some understanding of how it complements and/or contrasts with other perspectives or ways of organizing knowledge and inquiry.

According to Aikenhead (1992) the social isolation of traditional science teaching has discouraged bright and creative high school students from pursuing science careers. Therefore, he believes that teaching integrated courses in science and technology should improve the science literacy of all students including those going on to careers in science and technology. The National Science Teacher Association (NSTA Task Force, 1990) and the American Association for the Advancement of Science (AAAS, 1989a, 1993) described the qualities and capabilities of scientifically and technologically literate persons as those who: a) use concepts of science, technology and ethical values to solve everyday problems; b) recognize that science and technology are human endeavors; c) provide a scientific explanation for natural processes; d) locate, collect, analyze, and evaluate sources of scientific and technological information and use these sources in solving problems, making decisions and taking actions; and e) consider the political, economic, moral, and ethical aspects of science and technology as they relate to personal and global issues.

The working group in <u>Innovations in Science and Technology Education vol. II</u> (Layton, 1988) stated that there are two ways to develop integrated science/technology curriculum. One way is to replace certain concepts in the science curriculum with aspects of technology. This could be accomplished by preparing either optional units or source books for teachers. A second, more innovative way, is to provide new integrated science/technology projects . It was also suggested that integrated science/technology courses should be implemented at the secondary school level where the curriculum should move from the concrete to the abstract with a level of complexity that should increase with the child's cognitive development.

Integrated science and society

The 10-11 year old child is not concerned with world problems. Society, for a 10 or 11 year old, means home and the immediate environment. Therefore, science for this age group should be relevant to the immediate environment. But as the child grows older the view of society gradually increases to include community and nation. Concern with world problems appears around the age of 16-17 (Intergovernmental Conference on Environmental Education, 1978). For this reason at an UNESCO *ad hoc* meeting of experts on science education at Nijmegen in 1977, it was advocated that science curriculum policies for older students should be made more relevant and linked to society, and science courses should have three components: concepts, processes and social aspects. The experts at this meeting prepared a list of aims and objectives considered to be relevant to teaching science in a societal context. These aims stated that the student should to be able:

1. To understand the nature and limitations of scientific knowledge;
2. To appreciate that the application of scientific knowledge can lead to both beneficial effects (such as improvement of health standards) and

detrimental effects (such as environmental pollution) to society and the environment;

3. To appreciate that the earth's resources are finite; and

4. To understand the need for, and to develop the ability to make reasoned decisions based on relevant constraints;

5. To recognize his responsibility as an individual and a citizen (Intergovernmental Conference on Environmental Education, 1978).

Integrated science and technology in societal context (STS)

The STS approach to the teaching of science has developed in all industrialized regions of the world in response to social pressures to prepare citizens who are decision makers (Aikenhead, 1990; Boujaoude et al, 1995). This approach places the content of science (the facts, principles, concepts and skills) in a context in which real science operates on a day to day basis

Starting in the 1960s and continuing in the 1970s, 1980s and into the 1990s, industrialized countries have given much attention to improving the materials and the methods of teaching science and technology. This has had the effect of making the materials and the methods more relevant to the social and economic needs of those countries (UNESCO, 1986a, 1988, 1990b, 1990c, 1992). Much attention has been also given to designing and modifying classroom practices so that pupils are not simply presented with a body of scientific knowledge and conclusions, but also learn to discover, experiment and test facts and principles for themselves. In these industrialized countries it was recognized that the nature of science should be presented as a dynamic and problematic system of learning. They agreed that "... a dynamic innovative industrial economy requires people who are able to think for themselves, and to be imaginative and not merely apply and reproduce existing scientific knowledge or technological solutions" (UNESCO, 1986c, p. 55). For all the reasons mentioned above, science and technology have been reformed and improved over the past twenty years. The emphasis has been placed on the structure and function of science (Anderson, 1987) to prepare individuals to deal with everyday problems, not only to prepare scientists and engineers (Ebenezer & Zoller, 1993); and scientific inquiry has been "...presented as inquiry into personal, environmental, and societal problems to acquire information for decision making" (Trowbridge & Bybee, 1990, p. 426). It is widely suggested that science integrated with technology should be linked to real-life situations in order to improve its educational relevance to society, increase productivity and ameliorate the quality of life. Moreover, by linking science education to real life situations, students will be provided with knowledge and experiences that are relevant to their needs. Science integrated with technology also helps the student to be actively engaged in the learning process and makes science more meaningful in terms of outcomes and processes.

In the last decade there has been public concern about international problems affecting human health which are the results of malnutrition, famine, and personal hygiene (Chisman, 1990). It becomes important for a modern science courses to include some aspects of human food and nutrition as these issues play an important role in most science curricula. These are considered necessary topics to be implemented in every integrated science project since they contribute to the personal development of youngsters, to the social and political decisions in which people are engaged, and to the amelioration of the living conditions and the quality of life.

Improving the quality of life also depends on certain indispensable prerequisites: directing science education to all students, enhancing their understanding of natural and technical processes, and developing their creative and productive potential. However, for actual amelioration of living conditions, students will have to complement their knowledge and problem-solving capabilities with a productive social commitment by taking the future into their own hands, participating in public decision-making, and raising the quality standards of productivity (Lauterbach & Mehta, 1987). New York State Department of Education requires that students pass a course in STS at grade 9, before they may graduate (A. Snow, personal communication, February 20, 1998).

Therefore, taking social issues into consideration in the teaching of science and technology will contribute enormously to the quality of life in a nation.

In summary, the two studies of integrated science (UNESCO, 1979, 1990a) made a great contribution to reforming science education policies worldwide. They indicated that integrated science was a relatively new phenomenon at the secondary level. The projects described in this section also demonstrated a trend in integrated science toward the inclusion of programs in environmental education, health and nutrition, science-integrated technology and the interaction of science and society. These programs were intended for learners at all levels. Their goals were to increase the students' motivation and attitude, provide them with knowledge and skills and help them to link school activities with the world outside of school. It should be noted that the STS approach to science education has not been universally embraced. Although STS has been supported by many science educators (Ramsey, 1993) the question of whether to include STS materials into science curriculum at high school levels is still under debate (Solomon & Aikenhead, 1994).

Approaches to School Science Teaching

Hurd (1991a) stated that the new science courses of the future must be developed "... with a full recognition of recent developments in the cognitive sciences, putting students more in control of their own learning" (p. 258). In this section two currently important approaches to school science teaching and learning will be presented: constructivism and cooperative learning, both of which have emerged from the inquiry/process approach of the 1960s. In addition, other approaches that are considered important by educators and reformers in science education will also be reviewed briefly.

<u>Constructivism</u>

A theoretical approach which has had much influence on science education teaching and learning in the last decade is constructivism (Cheek, 1989; West & Pines 1985), in which learning is characterized as individual construction of knowledge (Cobb, 1994). The view that knowledge cannot be transmitted directly from one knower to another, but is actively built up by the learner, is shared by many researchers in science education (Driver, Asoko, Leach, Mortimer & Scott, 1994; Weatley, 1991). It is also believed that any account of teaching and learning science needs to consider the nature of the knowledge to be taught (Weatley, 1991). It is believed that knowledge is neither a commodity that can be communicated (von Glaserfeld, 1990) nor "...something that people possess in their heads, but something people do together." (Gergen, 1982, p. 270).

Constructivism views learning as the adaptations children make in their functioning schemes to neutralize perturbations that arise through interactions with the world (Steffe, 1990). Constructivism assumes that effective learning takes place when students construct their own meaning of an event. This can occur through active participation, reflection, and practice in transferring a scientific idea to an everyday context. It is believed that through participation, reflection, and practice, students can incorporate new ideas into their previous knowledge, or perhaps even replace their commonsense conceptions with more precise scientific conceptions (Aikenhead, 1992).

The Constructivist Learning Model (CLM) has been supported by cognitive science research. In this model, the emphasis is on the learner, and learning becomes an active process influenced by the learner, the teacher, and the school. From this perspective, learning outcomes do not depend on what the teacher presents but rather are an interactive result of what information is received and how the student processes it, based on perceived notions and existing personal knowledge (Yager, 1991a).

Yager (1991a) stated that according to the CLM, science teachers can move towards constructivist approaches using the following procedures: a) seeking out and using student questions and ideas to guide lessons and whole instructional units; b) accepting and encouraging student initiation of ideas; c) promoting student leadership, collaboration, location of information, and action as a result of the learning process; d) using student thinking, experience and interest to drive lessons; e) using open-ended questions and encouraging students to elaborate on their questions and their responses; f) encouraging students to suggest causes for events and situations, and also predict consequences; g) encouraging students to test their own ideas by answering their questions; h) seeking out student ideas before presenting teacher ideas or before studying ideas from textbooks or other resources; i) encouraging students to challenge each other's concepts and ideas; j) using cooperative learning strategies that emphasize collaboration, and respect for individuality;

k) encouraging adequate time for reflection and analysis; respecting and using ideas generated by students; and l) encouraging self-analysis, the collection of real evidence to support ideas, and reformulation of ideas in light of new experience and evidence (Yager, 1991a, p. 55-56).

Researchers at the National Center for Improving Science Education (NCISS) proposed a teaching model which uses the CLM (Yager, 1991a). It includes four aspects:

invitation: observing, identifying situations, asking questions and considering possible answers;

exploration: engaging in focused play, looking for information, experimenting, observing , designing, collecting and organizing data, evaluating choices, debating, identifying risks and consequences, and analyzing data;

proposing explanations and solutions: communicating information and ideas, constructing and explaining a model, reviewing and criticizing solutions; and

taking action: making decisions, applying and transferring knowledge and skills, sharing information and ideas, asking new questions, and developing products.

Constructivism has become an important feature of science teaching and has had an influence on curriculum development. Therefore it should be considered as a major influence when curriculum reform is planned for any jurisdiction.

Cooperative learning

Another teaching and learning strategy that effectively promotes student learning in science is cooperative learning. Cooperative learning is "...an instructional format in which students work together to achieve a particular goal or complete a task" (Hassard, 1990, p. 36). According to studies and research in this area, cooperative learning creates fruitful learning climates (South Carolina State Department of Education, 1990), enhances social skills among students and promotes the accomplishment of most cognitive and affective outcomes (Hassard, 1990; South Carolina State Department of Education, 1990). Johnson and Johnson (Johnson and Johnson, 1984, 1989; Johnson, Johnson & Holubec, 1996) found that cooperative learning environments are superior to competitive or individualistic environments for fostering social support, self-esteem and positive attitudes toward school and classmates. They also demonstrated that students like science classes better when they engage in cooperative activities and cooperative learning (Johnson et al, 1996). Kyle (1984) reported that in cooperative learning, lessons employ concrete learning materials and hands-on activities and focus on problem solving. These strategies encourage development of higher-level intellectual skills. Johnson, Johnson and Holubec (1996) agreed and added that "...students actively build skills through using them not by hearing about them... ...they [students] can monitor, guide, and encourage the practice of science skills" (p. 55). They continue that when students learn in cooperative groups in science courses they achieve better, use higher-level reasoning strategies more frequently, retain more in long-term memory, and are better able to apply what they learn to real-world situations compared to when they learn in a competitive or individual manner.

Other strategies

The literature also shows that teaching strategies emphasizing the use of games, simulations and role playing in science education (Molyneux, 1987) are claimed to raise students' interest and motivation. This is based on the fact that these strategies involve students' activities, group dynamics and a change in the classroom environment and teacher role (Molyneux, 1987). O'brien (1993) advocated using toys in science teaching across the K-12 school curriculum. According to O'brien "using toys to teach fundamental principles of science can be especially effective since toys build on and extend the out of school experiences of students." (O'brien, 1993, p. 204). He continued: "Toys help make otherwise abstract principles concrete and relevant to students' lives and demonstrate science in the real world vs. science in the science laboratory" (p. 204). The importance of integrating the uses of toys in teaching science was also recognized by Bybee and Landes (1990). They believed that toys can be used in any phase of the teaching process because they can be interactive, inquiry demonstrations, or in student-centered, individual or cooperative learning group. It is also recognized that learning is more effective if teaching involves the active participation of students, for example in the use of field trips, laboratory experiments, exposition, project work, decision making, discussion, problem-solving, and personal investigation (Stinner, 1995; Weatley, 1991).

It is probably true to say that in all curriculum development projects at the secondary school level of education which have been taking place in many countries today, the "learning by doing" child-centered approach which involves actively the student in the learning process, is the most recommended and emphasized. We can also conclude that no simple type of instructional materials, teaching style or approach is appropriate for all teachers, students and objectives. Variety is important in motivating students and teachers in the teaching and learning process.

This chapter will now describe science curriculum reform in the three countries chosen for the study. The influences described so far in this chapter will be apparent in the science curricula of the U.S.A., U.K., and Japan.

Science Curriculum Policy Reform in United States

Over the last few decades the United States has made a major contribution to the literature on science curriculum reform. The U.S.A. leads the world in a large number of scientific fields and its not surprising that, as is mentioned in the "Task Force on Science Policy Report" (December, 1984), many scientists from other countries seek to obtain part or all of their training by studying in the U.S.A. The literature also shows that many countries including the U.K. and Japan continually made use of educational materials developed in the U.S.A.

From the 1950s, as a result of the United States' concern with possible Soviet supremacy in space, a number of important changes took place in science curriculum policies in that country. These changes in science curricula for secondary school have continued to appear in all areas of science, even though the space race is no longer a focus of attention. The amount of research published in the area of science education easily confirms that the United States is the country which invests the most time, money, and effort in developing new materials and approaches to the teaching and learning of science. In the last decade a number of curriculum projects aimed at improving science teaching in the U.S.A. have been proposed by agencies such as the National Science Foundation (NSF), the National Science Teachers' Association (NSTA), and the American Association for the Advancement of Science (AAAS). These will now be outlined chronologically.

The National Science Foundation is a federal agency founded in 1950 whose goal is "... to develop and encourage the pursuit of a national policy for the promotion of basic research and education in sciences" (Gutesk, 1983, p. 299). The Foundation recognized the fact that American educational systems were facing some difficulties in trying to meet the needs of the nation in a changing and increasingly technological society. It also reported that many students lacked the understanding and necessary skills to participate fully in the technological world where they lived and would work.

Viewing these problems, the NSF stimulated a number of new programs and it also encouraged the examination and reorganization of science curriculum and instruction. The NSF claimed that the definition of science education needed to be expanded to include social issues related to scientific development and also to incorporate relationships between science and technology as well as education about science and technology (Brinckerhoff & Yager, 1987; National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1982)

The NSF, in cooperation with the U.S. Department of Education, prepared a series of reports on the conditions of science and engineering education in the U.S.A. in which some goals for reforming science curriculum policies were stated. These goals were further elaborated by Yager (1990; see also Yager & Tweed, 1991). They were: a) to continue to develop and broaden the pool of students who are well-prepared and highly motivated for advanced careers in science; b) to widen the range of high quality educational offerings in science and technology at all grade levels so that more students would be prepared for technically oriented careers and professions; c) to increase the general science and technology literacy of all citizens for life, work, and full participation in the society of the future (National Science Board, Commission on Precollege Education in Mathematics, Science and Technology, 1982; Yager, 1990; 1991b; Yager et al, 1991).

"Project Synthesis" (National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1982, 1983), which was supported by the NSF also recognized the fact that the goals of science curricula needed to be reformed and a new rationale, focus, and statement of purpose were needed. These new goals were to consider the fact that students would soon be operating as adults in a society which would be even more technologically-oriented (National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1982, 1983). Advances in technology in the past 15 years make this even more pertinent today.

The Science/Technology/Society (STS) group of Project Synthesis, with NSF support, formulated 27 recommendations (Brinckerhoff, et al, 1987; National Science Board, Commission on Precollege Education in Mathematics, Science and Technology, 1982, 1983). The following are the Project Synthesis recommendations closely relevant to this study: a) secondary school science courses should be more directed toward personal and societal problems involving science and technology in order for the student to be better equipped with the basis for understanding and dealing with science and technology; b) the development of curriculum materials should focus on national problems such as energy, health, and natural resources; c) new perspectives for teaching science are needed in response to the world's problems; d) teachers should be encouraged to develop STS materials to fit into their courses where appropriate; and e) State Education

Departments should encourage the inclusion of such materials into science courses at all levels.

The role of science as an enterprise is considered to be related to the role of technology (Brinckerhoff et al, 1987) since both of them operate within the same framework of basic concepts and scientific principles. In addition, science is viewed not only as a form of knowledge but also as having a social role in advancing human well-being and national interests.

The Exeter Conference on Secondary School Science Education (1980), involving 38 secondary school teachers and ten specialists in science from across the United States recommended that societal and ethical consequences of modern science and technology should become a part of the science curriculum. It also demanded that materials that place the study of science into a societal context be infused into existing programs and curricula. These materials must give the student the opportunities to experience scientific knowledge not only in the school science laboratory but also in the community, which constitutes a major source of materials. Students must be confronted with problems which, unlike those raised in the usual science programs, do not lead inevitably to a simplistic, uniquely correct answer. Real societal issues give rise to a variety of possible solutions each providing some benefit but only at some cost, and students should be aware of this.

Congruent with the NSF and the "Project Synthesis", Bybee undertook to reform science curriculum policies in the United States. His work presented in "Science Education Policies for the 1980s and Beyond" and reported to the U.S. Department of Science Education, proposed guidelines for policy reform based on projections for the 1990s and beyond (Bybee, 1980). The new directions and the general policies for future science education relevant to this study are:

1. Science and society goals will be the organizational core of curriculum.

2. Scientific knowledge in the context of science related social issues, and scientific method will be presented as inquiry into personal, environmental and social problems to provide information for decision making.

3. Laboratory activities will provide opportunities to solve problems, to learn inquiry processes and to develop decision making skills.

4. Interdisciplinary approaches will be used. Science, technology and society interdependence will be stressed. Science will be presented as an ever-changing body of knowledge having important influence on society.

5. Career information will be directed to multiple scientific and technological occupations for all persons (Bybee, 1980).

The trends in science curriculum policy are directed toward an interdisciplinary approach to science, based on possible directions of social change. They are also directed toward fulfillment of the student's basic needs, the improvement of the physical and human environment, and the development of a better community. Therefore science curriculum policies should be developed in a way that contributes to the preparation of students for life as responsible individuals in a society where they are confronted with world problems.

The National Science Teachers Association (NSTA), in their position statement on Science Education for the 1980s (NSTA, 1982), reported on the goal of science curriculum policies for the 1980s and beyond by stating that the goal was to develop scientifically and technologically literate individuals. The NSTA listed 13 attributes that help to describe a scientifically and technologically literate person. The attributes most relevant to this study are: a) use of science concepts, process skills, and values in making responsible everyday decisions and in helping the individual to continue to learn and think logically; b) recognizing the usefulness of science and technology in society and understanding their limitations; and c) understanding how society influences science and technology as well as how science and technology influence society.

In order for the population of the nation to be scientifically and technologically literate, schools should provide adequate curriculum. Therefore, according to the NSTA, science in secondary school should be reformed to meet the needs of the nation. It recommended that secondary science curriculum should be designed:

1. To meet the needs of students by providing them with daily opportunities to explore science through direct learning experiences in the laboratory and field work.

2. To continue to develop science process skills and content with an emphasis on their application to the students' personal life situations. These skills should also help students identify science-based societal problems and make decisions about their resolutions.

3. To require secondary school students (grade 7-12) to take a minimum of one hour of science per day for at least four full years. The courses should represent a balance of physical and life sciences. A minimum of 15-20% and ideally 20-30% of science instruction should be directed toward science-related social issues (Bybee, 1980).

4. To adopt an interdisciplinary approach to science education including environment studies, health and nutrition education. (Bybee, 1980; NSTA, 1982).

The proceedings show that some initiatives were proposed for policy reform in science education in the U.S.A. These initiatives dealt with the importance of relating science to technology by preparing students for technically oriented society and providing them with an adequate science curriculum. Secondary science courses should be interdisciplinary and focus on national problems such as energy, environment and nutrition. These science courses should be aimed at developing science process skills and content with an emphasis on their application to the student's personal life situation. Finally, societal and ethical consequences of modern science and technology should become a part of the science curriculum

An example of one curriculum development project based on the work of the NSF, the NSTA and Bybee in reforming a new direction for science curriculum policies, was developed by Hurd (1984). He proposed a new biology curriculum that he called "biology for life and living". According to Hurd such a curriculum should be oriented toward studying and learning in the future since we cannot ignore the fact that life is lived forward and not backward. He advocated that: "If biology teaching is focused on life and living, then the subject matter must be chosen for its value in understanding the present and the future." (Hurd, 1984 p. 8). He added that: "This does not mean the lessons of the past are to be forgotten, but rather taught as they influence the present and guide the future." (Hurd, 1984, p. 8). Hurd concluded by stressing the fact that " biology for life and living" should include many scientific areas that consider human nature and the character of human culture.

These areas offer information that should help to develop healthy, responsible human beings who can fulfill their obligations to themselves, to each other, and to society. Students must be taught how to solve contemporary problems which manifest themselves every day in ecological, health and energy situations. Therefore in order for them to be better prepared for the years to come, science curriculum in general should stress an interdisciplinary approach to science and be designed to help students to know how to obtain information, influence actions, and cope with challenges.

The work of the NSF, the NSTA, Bybee and Hurd leads us to conclude that the trends in the objectives, aims and content of science curricula for the 1990s and beyond are probably toward science courses that meet the needs of students who must cope with world problems now and in the future. They consider that the basic issue of education policies for the future would be an interdisciplinary approach to science education, represented by integrated sciences with an emphasis on environmental problems, and science-and technology-related issues within a societal context. Such policies would provide students with a scientific education that would help them to cope with changes and search for solutions to their everyday problems.

In the latter part of the 1980s science curriculum projects were developed with the support of the NSF and based on the position statements of the 1960s and 1970s. Some of these projects at the middle school levels are listed here.

1. Project 2061, Science for All Americans; a project developed by the American Association for the Advancement of Science (AAAS) is designed to help reform science, mathematics, and technology education. Its central goal is to seek answers to questions related to scientific literacy. Six basic dimensions of scientific literacy were identified: a) being familiar with the natural world and recognizing both its diversity and its unity; b) understanding the key concepts and principles of science; c) being aware of the important ways in which science and technology depend upon one another; d) knowing that science and technology are human enterprises; e) having a

capacity for scientific ways of thinking; f) using scientific knowledge and ways of thinking for individual and social purposes (AAAS, 1989b, 1993). The project emphasis is on a new core curriculum that shows fewer topics than the traditional curriculum, so that all students can concentrate on learning well a basic set of ideas and skills that will lead to scientific literacy and promote further learning, which providing opportunities for students to go beyond the core in response to their individual interests, talents, and plans for the future. All students in project 2061 will have broad learning experiences such as hands-on activities, and reflective thinking. These learning experiences enable students to make sense of their experiences, and engage them in using their knowledge to explain everyday phenomena, to solve practical problems, and to inform decisions about issues. For these learning experiences to take place in a natural setting, students and teachers are encouraged to leave the school grounds to participate in activities in the community or to learn science in the field rather than in the school (AAAS, 1993).

2. The NSTA Project on Scope, Sequence, and Coordination of Secondary School Science (SS&C). The SS&C project is similar to "project 2061". It is intended to make science accessible to all students. It suggests that instead of giving separate science courses, American science education could be improved by spreading the separate science courses over the four years of a student's secondary education, with content from each of the sciences being taught each year in a manner appropriate to the student's level of cognitive

development (Aldridge, 1989). The SS&C project "... advocates presenting key science concepts appropriately sequenced, manageable in their scope, and coordinated within and between the science disciplines" (NSTA, 1993, p. 2). In addition, the SS&C project advocates that since student experiences precede the mastery of terminology, the constructivist approach to learning would be the most appropriate instructional strategy proposed by this project (NSTA, 1993).

Project 2061 and SS&C project were used by the National Research Council (NRC) in the development of national standards for science education goals, content, teaching and assessment. The work was founded by the Department of Science Education and the NSF (NRC, 1996). The "National Science Education Standards" are designed according to the aims of Project 2061, specifically to enable the nation to achieve scientific literacy which is of increasing importance in the workplace and is a necessity for everyone living in the 21st century.

The development of the "National Science Education Standards" was guided by four principles. 1. science is for all students; 2. learning science is an active process; 3. school science reflects intellectual and cultural traditions that characterize the practice of contemporary science; and 4. improving science education is part of systemic education reform (NRC, 1996).

The "National Science Education Standards" apply to all students who can develop the knowledge and skills. Students who can go beyond these standards are provided with advanced courses that enable them to achieve different degrees of depth and breadth of understanding.

3. The University of Alabama's Center for Communication and Educational Technology (CCET). The University of Alabama developed a curriculum reform project for middle school called "Integrated Science". It is a three year program based on the work and recommendations of the AAAS (Project 2061) and NSTA (SS&C). The program goals are to stimulate student interest in science and produce more scientifically literate adults. It is developed to serve all types of students. The first course, introduced at the grade 7 level during the 1991-1992 school year, was followed by courses for grade 6 and 8. The Integrated Science program emphasizes the development of problem solving skills and the mastery of key concepts. The NSTA's recommendations on instructional strategies that emphasizes constructivism have been adopted into teaching of this program (University of Alabama, n.d).

The projects described above share some important characteristics: the curriculum materials are designed to help children develop an understanding of key concepts; they also emphasize hands-on activities along with the development of problem solving skills; science concepts are related to social and environmental concerns; and science is taught as an integrated subject.

These projects illustrate that the trends in the 1990s in teaching strategies in the U.S.A. are toward the use of materials and approaches that reflect the idea that learners construct their own knowledge, based on their observations and experiences. It is stated that if learners' self-constructed knowledge differs from the concepts presented in formal science instruction, curriculum materials and instructional approaches must be used that bring about conceptual change. Learners must be involved in experiences that challenge their current conceptions. Opportunity must be given to learners to apply new concepts and evaluate their adequacy. Student perceptions should be taken into account when planning curriculum and instruction. Hands-on manipulative activities, and students working in cooperative learning groups should be among the suggested teaching strategies (Weiss, 1994). Finally, in the 1990s and beyond, instruction should involve interaction among teachers, students, and materials, rather than the transmission of knowledge from teachers to students. Instructional materials should reflect advances in technology (such as the uses of computers, videodisks, computer networks such as the Internet, and so on) and should also involve the use of community resources (ERIC/SMEAC Science Education Digest, 1990).

The foregoing shows that current efforts to reform science education in the U.S.A. began with the development of three important projects. All these projects, with the goal to develop scientifically and technologically literate individuals, have shared common recommendations. They stress the interdisciplinary approach to science, based on social changes, and the importance of directing secondary school science courses toward personal and societal problems. They demand that existing curricula should include materials that place the study of science in a societal context. School science curriculum should contribute to the preparation of responsible individuals by providing students with skills to help them identify science-based societal problems and make decisions about their solutions. They advise that students should be engaged in meaningful activities that enable them to construct knowledge and then apply it. They all believe that cooperative learning is important for effective instruction, and student preconceptions about a topic should be taken into consideration when planning science curriculum and instruction.

Science Curriculum Policy Reform in U.K.

Secondary school science teaching and learning in U.K. has been strongly influenced by a series of curriculum development projects carried out by national organizations and associations such as the Nuffield Foundation, The Schools Council, The Royal Society of Chemistry, and The Association for Science Education. These projects are evident in the National Curriculum (1988).

In the 1960s The Nuffield Foundation generated projects in biology and physical science (Waring, 1982). These projects were developed to suit the pattern of science education which existed at the time and to give new emphasis to science in terms of both approach and content. The content of the Nuffield projects stressed the scientific enquiry which was translated as guided discovery. Materials that deal with biochemistry, molecular biology, ethnology and ecology were included in these projects in addition to topics in genetics and evolution that were regarded previously as difficult and unsuitable for students. The Nuffield Foundation Projects replaced existing traditional science courses which had changed little since the late 19th century (Waring, 1982). These projects demonstrated not only how necessary instructional materials could be created and how teachers could be trained in their use but it also stimulated many other projects in U.K. Concurrent with the Nuffield Foundation projects, The Schools Council produced a curriculum project in order to improve school science teaching and learning. This project, "The Schools Council Project Technology", recommended and supported:

1. The production of technological materials that aid the teacher in developing technological work in schools (the Project prepared handbooks describing the construction of suitable apparatus).

2. The development of suitable examinations that encourage technological work.

3. The initiation of teacher training. In some areas, Science and Technology Centers were established to train the teachers. (Pedagogica Europea, 1973)

In 1981, The Education Division of The Royal Society of Chemistry (RSC) made proposals for the teaching of science to all pupils up to the age of 16 (Science Education Newsletter 1, 1981). It suggested that pupils should follow a balanced science curriculum for the first three years of school as they were doing and then all pupils might continue with eight periods of science per week in one of the following areas:

- eight periods integrated science; or
- four periods physical science plus four periods biological science (with chemistry split between the two); or
- four periods core science (Physics and Chemistry and Biology) plus four periods of optional modules leading to examinations in single subjects (Science Education Newsletter 1, 1981, p. 2).

It is widely accepted in U.K. that science should have a place in the education of all young people of compulsory school age whether or not they go on to follow a career in science or technology (Lawton & Chitty, 1988). For a practical improvement in science curriculum policies in U.K., a wide-ranging Bill was passed in 1987 set out to improve the quality of general education. The Secretary of the State for Education and Science established a National Curriculum, including arrangements for assessment and testing, and the approval of teacher qualifications. The general aims of the curriculum were to promote the development of pupils and society and to prepare pupils for entry into adult life. The National Curriculum incorporated proposals from the Secondary Science Curriculum Review (SSCR), the Department of Science Education (DSE), the Association for Science Education (ASE), and the Royal Society that: a) education through science is an important component of general education and should be recognized as part of the core of the curriculum; and b) all students should be given the opportunity to benefit from a full and effective program of science education throughout their period of compulsory schooling (Central Office of Information, 1988).

A review of the work and the statements of these official educational organizations illustrate their recommendations for a new direction in science education. These recommendations will be detailed here.

At the secondary school level all students must benefit from a broad and balanced curriculum. This can be accomplished by providing the students with the opportunity to explore the nature of the biological and physical environment through observation, experiment, and systematic inquiry. Students also should use their knowledge of science to design and develop solutions to technological problems and to test and evaluate these solutions. They should discuss, reflect upon and evaluate their own personal understanding of key scientific concepts, theories and generalizations (Central Office of Information, 1988; DESWO, 1985; Science Education Newsletter 56, 1984).

At the secondary school level science content should be structured in a way that all pupils may benefit from an introductory course in science. Science for all students up to the age of 16 should include an appropriate level of basic concepts of biology, chemistry, and physics (DESWO, 1985). Integrated courses that cover basic science, astronomy, nutrition and health, environmental problems, energy education, and topics in science and technology should also be provided (DESWO, 1985; Science Education

Newsletter 61, 1985). Courses need to be developed which foster the essential scientific content, skills, and processes while at the same time providing opportunities for related technological work (DESWO, 1985). Science education should be presented and assessed in a way that allows pupils to see its direct relevance to their lives; it should draw on the environment and experience of the pupils themselves (DESWO, 1985).

It was also recommended that a broad science curriculum for the secondary school level should require that all pupils study science throughout the first three years, allocating 10% of the total curriculum time to science in the first two years, and 15% in the third year (Science Education Newsletter 61, 1985; UNESCO, 1990c). The most common pattern would be a course in combined science in the first two years, often followed by a separation into physics, chemistry, and biology in the third year. These science courses often include a simple introduction to astronomy, microbiology, and elements of environmental and earth science (Science Education Newsletter 66, 1986). For year four and five, the maximum time allotment of science would be about 20% (and ideally 30%) of the total curriculum time (8 or 9 periods in a 40 period week). Each pupil would be entitled to a program of study which, however it was organized, would incorporate substantial elements from each of the three main sciences (Science Education Newsletter 78, 1988).

The National Curriculum, initiated in 1988 and implemented in the 1990s, included science (with English and mathematics) as one of three core school subjects (Whitaker's Almanack, 1996), with the added recommendation that science should be taught as an integrated subject to the end of grade 10 (Lawton & Chitty, 1988). The goals of the revised program in the U.K. closely parallel the AAAS' Project 2061 (Gardner, 1991). At A-level, two courses are offered in most school subjects including science taken by students seeking to go on to higher education (The Sunday Times, 1993). According to Gardner (1991), science commissions, study groups, and even textbook publishers in the U.K. are working together to create a national consensus on how science education should proceed. They are trying to set new educational goals in science.

The examination system in the U.K. has been subject to reform during the last two decades. The first reform took place in November 1982 when the government proposed the introduction of a new single system of examinations for students sixteen years and older. Work on the national criteria of twenty subjects including science was undertaken by a Joint Council representing all examination boards. This resulted in the reorganization of the General Certificate of Education for 16 year olds (GCE O-level) and the Certificate for Secondary Education (CSE) for 16 year olds into the General Certificate of Secondary Education (GCSE) to be taken by most pupils at the end of their fifth year in secondary school (16+) (BBC Radio for Schools and Colleges, 1984). Syllabi designed on the basis of national subject criteria were introduced in Autumn 1986 and the first exam took place in June 1988. These criteria include not only knowledge of the subject, but also skills, processes, and industrial and technological applications. Teacher assessment of practical skills and also of coursework and projects contributes a significant part to the overall grade. It is no longer possible for pupils to finish their schooling without having had their practical science skills assessed formally. There are also demands on the pupils' abilities to understand rather than to memorize facts (Central Office of Information, 1985; Feature, August, 1988).

The second reform of the examination system took place in 1988, with the introduction of the National Curriculum. The introduction of the National Curriculum allowed the implementation of Standard Assessment Tasks (SATs) which means that at the secondary school level students aged 14 and 16 are assessed in science toward the end of the school year (Education Information Section, 1995). A new School Examinations and Assessment Council (SEAC) was set to review assessment and examinations (Lawton et al, 1988; Pring, 1989). The first assessment in science at age 14 took place in the Summer of 1993 (The Sunday Times, 1993) and the first assessment for GCSE, A and AS levels based on the National Curriculum took place in the Summer of 1994 (SCAA, 1995a; 1995b; Whitaker's Almanack, 1996). Students' results in these assessments were considered to be good and demonstrated that the revised science curriculum was successful (SCAA, 1995a; 1995b; The Sunday Times, 1993).

In addition to the established single subject examinations, there are an increasing number of syllabi incorporating aspects of the three separate sciences in a single examination. Many of these are termed "double award" since pupils gain two GCSE grades in science at the end of the two year course

(SCAA, 1995a; Science Education Newsletter 78, 1988). Parallel reforms in examination policies have not taken place in the U.S. and Japan.

Reform in teaching strategies also took place in the U.K. In "Science 11-16: A Statement of Policy" (DESWO, 1985), it was recommended that science instruction to pupils up to age sixteen should be closely related to everyday and industrial applications of science. It should foster problem solving, investigation, practical work, exposition, discussion, consolidation and practice. Such teaching approaches seem, according to the Secretary of State, to be essential for the teaching of science. Pupils should be given the opportunity to test their own ideas, to engage in experimental work in which a variety of practical work and investigative skills should be developed under the supervision of the teacher. For better teaching the Policy Group of the Association for Science Education (ASE) has recommended that, for practical work, all classes should be limited to a maximum of twenty pupils and that resources for science teaching at the secondary level be improved (ASE, 1981).

The foregoing shows that, as in the U.S., science education in the U.K. has also been subject to a major reform in the past few decades. Science content, the examination system as well as teaching strategies were subject to reform and innovation. This is the result of the influence of a series of curriculum development projects carried out by national organizations and associations and by a mandate from the central government. These projects were aimed at providing all students an effective science program throughout the period of compulsory schooling. They also propose that at the secondary school level, all students should benefit from a broad and balanced science curriculum in which all science courses include appropriate levels of basic concepts in all science disciplines. In addition, they require that all science courses should have a technological content and foster skills and processes. Assessment in science, they suggest, should be designed to include, in addition to knowledge of the subject, the skills, processes, industrial and technological applications. Finally, they called for teaching strategies that are related to student's everyday experiences and foster problem solving.

Science Curriculum Reform in Japan

The educational system in Japan underwent extensive reform after World War II. The Constitution, established in 1946, defines (Article 26) the basic right and duty of the people to receive education as follows:

> All people shall have the right to receive an equal education correspondent to their ability as provided by law (Public Information, Bureau, Ministry of Foreign Affairs, Japan: Facts about Japan, 1976, p. 2).

The Fundamental Law of Education, established in 1947, sets forth in more detail the aims and principles of education in general, and of science education in particular. The central aim was defined as raising self-reliant citizens in a peaceful and democratic state and community with respect for human values (Public Information, Bureau, Ministry of Foreign Affairs, Japan: Facts about Japan, 1976).

In the 1960s, a revision of science curriculum policies began in Japan, and science teaching was invigorated. In grades seven through nine, four hours per week of science courses were required, which was not enough time to cover all the subjects adequately. This resulted in a neglect of laboratory work. There was a general feeling that a revision of several parts of the science curricula would be an asset. Therefore, the Ministry of Education in the 1970s called for a revision of science curriculum policies based on Japan's remarkable progress in natural science and technology and intended to help Japanese youths cope with progress in the present and in the future (Ito, Nakayama, Shibanuma, Beppu, Hayashi, & Oki, 1975). This involved adding more material to the curriculum and making instruction more flexible in order to meet the individual differences of the students. One of the contexts that was added to the curriculum at that time was "Basic Science" a collection of topics in chemistry, physics, biology, and earth science. It was believed that through studying "Basic Science" the student would be provided with complete ways of thinking and observing nature (Ito, et al, 1975). In this manner, Japan could "keep pace with rapid progress in science and technology" (Cooper, 1983, p. 93).

In December 1976, Japan established a "Curriculum Council" to improve science curriculum policies at all secondary school levels. Its aims were: a) to make the school life of students freer and more enjoyable without lowering the educational standards; b) to achieve well-selected and balanced content for individual subjects where basic science, physics, biology, chemistry, and earth science constitute required subjects for all students in upper secondary school; and c) to establish a coherent consistency and relevance in all curricula (Direction générale de l'information, Ministère des affaires étrangères, Japon, 1979).

The Curriculum Council also recommended that at all levels of teaching, science education and technology occupy an important part in the program (Ministère des affaires étrangères, 1983). Accordingly, an overall revision of the Course of Study took place in the lower secondary school in July 1978, and in upper secondary school in August 1978. The revisions were put into effect in 1981 and 1982 for the lower and upper secondary levels respectively.

In the revised lower secondary school science curricula, the following three points were particularly emphasized: a) the stress on the formation of basic scientific concepts and learning by inquiry should continue with special attention to teaching in accordance with the mental and physical development of the child; b) there should be a careful selection of the content of subject matter in order to emphasize what is basic and fundamental; and c) science teaching should include learning about the relationship between nature and man. In other words, basic knowledge about natural resources, energy problems and protecting the environment must be taught in the appropriate way (UNESCO, 1984).

In the revised upper secondary school science curricula, two new integrated science courses replaced "Basic Science". These were: a) Science I which is a required subject for all students at grade ten level. Its topics were carefully selected from physics, biology, chemistry, and earth science. The concept of energy is also taught (Matter and Energy); and b) Science II, intended for students who want to learn additional science after they have completed Science I, and stressing science process skills. In Science II, students study the methods of science and select appropriate topics independently (Direction générale de l'information, Ministère des affaires étrangères, Japon, 1979; UNESCO, 1984).

Recently, another revision of the national course of study for lower and upper secondary schools in Japan has taken place (Umeno, 1992). The new revision should have been put into practice in 1993 for lower secondary schools and in 1994 for upper secondary schools (Ministry of Education, Science and Culture, 1989a; 1989b). However, there is no indication in the literature whether the new revisions have been taking place. The revised course of study makes it possible for student at the lower secondary level to select some subjects according to their abilities and preferences. At the upper secondary level, students have a variety of optional courses to choose from. These courses emphasize relationships between science and human life as well as the applications of science. At each school level, the content of science was carefully selected in light of changes taking place in society (Umeno, 1990). Observation and experimentation are more emphasized in the new revision than before. This revision was in part a response to the findings of the Second International Science Study (SISS) conducted by the International

Association for the Evaluation of Educational Achievement (IEA). The SISS found that Japanese students achieved poor grades in the practical tests in contrast to their results in written tests, in which they achieved top grades (Umeno, 1992). The explanation for the poor results in practical tests is associated with the belief that still not enough time is spent on observation and experimentation in studying science

In Japan in the early 1980s the trends in teaching science were toward the use of experiments, laboratory activities, and project work It was also suggested that in the teaching of content, the local environment and the schoolyard should be used in order to cultivate an ability to inquire into nature and to formulate fundamental concepts (Ministry of Education Science and Culture, 1983a). It is strongly believed that effective teaching in Japan at the secondary school level depends largely on the use of instructional materials that are found in the community that constitutes the school environment (Nogami & Jacobson, 1987).

As in the U.S.A. and the U.K., the educational system in Japan underwent reform. Changes took place in all the aspects of the science curriculum. Aims, objectives, science courses, content, and teaching methods were subject to revisions. The reform was aimed at achieving well-balanced content for science courses, in which technology should occupy an important place at all school levels. Energy was recommended as a concept to be taught in all compulsory school science. The reform also stressed learning by inquiry and the use of the local environment.

Summary

We can conclude that, in the three industrial countries under consideration, science curriculum policies have been subject to reform over the past 20 years. This is the same time span that Lebanon has been at war and recovering from the effects of the war. The three industrial countries have attempted to review their science curricula to make them more relevant to the needs of individuals and society, not just by integrating the basic sciences into a unifying whole, but by integrating them with wider issues in order to show the relevance of science teaching to all that goes on outside the classroom.

In all three countries it is generally believed that science education will make citizens more useful and productive. To accomplish this, science curriculum should not be removed from the problems of everyday life, and should build up knowledge for later studies in science disciplines. It should be practical and introduce the child to real world living. This implies that technology-related issues, should be a component of the curriculum. The three countries agree that science cannot be divorced from technology; the two should be linked, together with society. Therefore, science teaching cannot be separated from technology and technology cannot be separated from principles embodying the knowledge of science. In this manner as stated by Vohra (1987) "...in the process of education, whereas science will aim at providing information and experiences to deal with 'what is' or 'to know', technology will help in providing information and experience to deal with 'knowledge' or 'to do' (Vohra, 1987, p. 417). Today, it is believed that learning is more effective if it is activity-based, if it takes place in the context of doing, with constant interaction between knowledge and its application in everyday life and experience.

A number of curriculum projects aimed at improving science teaching have been developed in U.S.A., U.K., and Japan. These projects recommended that science education policies should be directed toward an interdisciplinary approach to science represented by integrated science courses which have an emphasis on environmental problems. Such policies should be developed in a way that contributes to the preparation of students for life, and provide them with scientific education that would help them to cope with changes and search for solutions to their everyday problems. They also agreed that appropriate levels of basic concepts of biology, chemistry, physics and earth sciences, should have a place in the education of all students.

The U.S.A. and U.K. recommended that secondary school science courses should continue to be directed toward personal and societal problems, involving science- and technology-related issues in a societal context.

In the U.S.A., the goal of science curriculum policies for the years to come is to develop scientifically and technologically literate individuals. To accomplish this, it was recommended that secondary school students be required to take a minimum of one hour of science per day for four years with approximately 20-30% of science instruction devoted to science-related social issues. The U.K. demanded that all students at the secondary school level be able to benefit from a broad and balanced curriculum. In Japan, the relationship between man and nature is given great importance in science curriculum which includes topics dealing with natural resources and energy problems at all school levels. Dealing with teaching strategies, the countries studied agree that science learning cannot be effective without good teaching materials and approaches that reflect the fact the learners construct their own knowledge based on their observation and experiences. They also stressed the use of problem solving, practical work, investigation, decision making, games, simulations and project work, in a word, everything that involves the student in an active way and demands the direct participation of the student in the learning process. In this manner science becomes enjoyable and relevant to the needs of the student and becomes a part of the students' world. The results of these policies and curriculum decisions have been demonstrated by the success of students in international studies (e.g. TIMSS) (Science Education Newsletter 134, 1997).

Finally, the philosophy of each of the three countries may be summarized by the National Academy of Science that "As we approach the twenty-first century, science must be accepted as a basic subject that must be taught in an understandable fashion to all students." (National Academy of Sciences, 1990, p. 5).

Chapter 3 The General, Historical, Cultural, Political and Economic Context of Lebanon and Its Educational System

Lebanese interest in the sciences can be traced back to the tradition of the Phoenicians who were the first to introduce the alphabet and make use of letters. They were also known as very talented people in scientific inquiry and discovery. For example: Phoenicians were the first to sail in the sea by using the trunk of Lebanese cedar trees as masts. In the 20th century, living conditions in the country have led to the exodus of its scientific community which has been re-established in Europe and the U.S.A. In the 20th century, there is no evidence of a science tradition in Lebanon. As the 20th century society becomes more science-based, and as the economic development and the growth of a country increasingly relies on well-educated citizens there is a need for a scientifically literate population as well as people trained as scientists. Therefore, there is a need for change in policy and an updating of the school science curriculum in Lebanon.

For a better insight into science curriculum policies in Lebanon, it is important to become familiar with the three major societal contexts that influence Lebanese society today. These are socio-cultural, economic, and educational and will be discussed in the section that follows.

Socio-Cultural Context

Lebanon is a unitary republic which achieved independence on November 22, 1943. It occupies a mountainous land along the Eastern Mediterranean shore. Lebanon's location allowed access to the external world and hence its traditional role of intermediary between West and East. It has an area of 10 452 km^2. Most of the population lived in cities, mainly in Beirut and its suburbs (50% of the population in 1973) but this situation changed during the war period (1975 - 1992) when a large internal migration to rural areas began and continues. The size of this migration is difficult to estimate.

Lebanon has been known as a country in which students are strongly oriented toward science. The Faculty of Science at the Lebanese University (L.U.) for example, registered an enrollment of 8256 students for the 1992-1993 school period. This is especially significant in light of the relatively small population of some 3 million people (CERD, 1993). According to some experts in the field of education and science (El-Amine, 1994), the Faculty of Science at the L.U. is still a highly regarded center which attracts many students.

Economic Context

According to a study carried out by UNESCO (1983b) Lebanon was found to have a Gross Domestic Product (GDP) per capita in 1979 of $1113 (US), and to be just below the line which separated less developed from industrial countries. However the economic situation has deteriorated in recent years because of the political situation.

In general, natural resources in Lebanon are very limited because the country has little arable land, few minerals and no known oil deposits. However, it does have two important assets, its human resources and its scenic beauty. Throughout the centuries the Lebanese people have been known for their skills, energy, enterprise, and adaptability to new ideas and techniques (Encarta, 1997). Thus, despite the relative poverty in natural resources, in 1982 Lebanon enjoyed the highest standard of living in the non-oil Arab countries (UNESCO, 1983b).

In the past, Lebanon relied on agriculture and services for its Gross National Product (GNP). Industry only started to prosper in the 1960s. Today, excluding the war, services constitute the most important element of the Lebanese economy. Services include commerce, entertainment, storage and transit traffic, and international financial transactions (Corm, 1986; Zouain, 1994). In the Lebanese economy, the tertiary sector has been predominant, due to the prosperity of trade, banking, tourism and transit. In 1970, the sector contributed 69% of the GNP and employed 56% of the labor force while the agricultural and industrial sectors contributed respectively 19% and 25% of the labor force. The destruction of many industrial suburbs since 1975 has progressively increased the share of services to about 80% of the GNP (Encarta, 1997; Zouain, 1994).

Since independence, the trade balance has always been negative. The value of exports has varied between 20% and 40 % of the value of imports. However, the balance of payments has shown surpluses of between 5% and 40% of the value of imports. This is due to the influx of capital to Lebanese banks, tourism, triangular trade transactions operated by Lebanese business institutions and to the earnings of Lebanese immigrants in oil-rich Arab countries. The increase of emigration (of mainly technical and professional people) since 1975 has increased the flow of capital into the country and has thus compensated for the drop of industrial exports. As the country gets richer, it becomes more stable, and this situation has been instrumental in not only providing more resources for education, but also in encouraging interest in science education.

Educational Context

The present system of education in Lebanon was built up under European and American influences. Schools of the Western type were established during the Mutasarrifiah period of autonomy (1861-1914) through the efforts of missionaries. For example, in 1866, an American Presbyterian mission founded the American University of Beirut (AUB). The French system of education was implemented during the French Mandate (1921-1943). During this period, instruction was limited to a political and intellectual élite. Since independence (1943), the number of schools and universities has been steadily increasing. Under the influence of the French and American systems of education, a Lebanese system has slowly emerged.

The main feature of this system is the importance given to the study of languages. At every level of schooling, students learn two languages: Arabic (the official language) and either French (approximately 75% of all school students) or English (25%). Students frequently learn one of these as a third language, starting at the age of 11. The majority of Lebanese are bilingual and many are trilingual (Aboumurad, 1985; Bashour, 1979; Lebanese Ministry of Planning, 1972; Zouain, 1994).

In Lebanon, there are both private and state (or official) schools and universities. Private institutions are supported financially by student fees and attract students from the high and middle income strata of the population. State (non-denominational) institutions are operated and supported financially by the government and their students come from low and middle income groups.

Statistical data on student enrollment have not been regularly published. A statistical study published by the Center for Educational Research and Development (CERD, 1993) shows that around 58.75% of school age children from kindergarten to high school level attend private schools, whereas the percentage is only 41.25% for the public schools. Parents prefer to send their children to private institutions where the quality of education is believed to be better.

Higher education is given particular attention in Lebanon. In Beirut and its suburbs, there are fifteen universities and institutes of higher education with different religious and/or national affiliations. Their presence makes Beirut an important regional center for higher studies and attracts students from the whole Middle East, Africa and Asia. Before 1975, about half of these students came from outside Lebanon. In these institutions instruction is offered in Arabic, French or English, depending on the university and on the subject, with all scientific subjects offered in English or French. After 1975, the Lebanese University (L.U.) opened new branches in the three main regional cities to help students solve traveling difficulties due to prevalent security conditions. This policy was also adopted by Université Saint Joseph (U.S.J.), a private institution located in Beirut (Zouain, 1994).

Administration of education

In Lebanon, responsibility for education is vested in the central government represented by a highly centralized ministry of education which formulates educational policy for the entire country. The ministry finances public education at all levels, administers all public schools below the university level; advises on educational planning, curriculum and school equipment; collects statistical data on education; trains, promotes and recruits teachers; plans and coordinates the implementation of curricula in all public schools; selects the books to be used; and administers public examinations. In short, virtually every aspect of education in the country is planned and administered by the central ministry (Ministry of National Education and Fine Arts, 1971).

Unlike the official system, the private school system is decentralized. Until 1949-1950, with the exception of one model school, private secondary education in Lebanon was completely a function of the private national, and foreign schools. This is still largely true today. The Lebanese Ministry of Education imposed, as it still does, a measure of uniformity over the curriculum and standards of the various private schools through a system of examinations for the Brevet (the fourth year of the lower secondary level) and the Baccalaureate (the second and third years of the upper secondary level), the only qualification recognized by the government (Bashour, 1979; Ministry of National Education and Fine Arts, 1971). This has forced private schools to observe the guidelines of the official curriculum and their students to sit for the national examination.

Science curriculum revision and reform from independence to the present.

Since 1932, with the Ministry of Education working through special committees, the science curriculum and syllabus has been revised several times. In 1932, the French school curriculum was adopted by Lebanese schools. In 1968, the Lebanese Ministry of Education announced new programs in science education. All these programs claimed modernization (UNESCO, 1968). The last version was another variation of the French program: a collection of titles defined in very vague form (Bashour 1979;

Badro et al, 1980). Legislation passed in 1971 by the Lebanese parliament created the Center for Educational Research and Development (CERD) which started operating in 1972 with the aim of improving science education and developing curriculum appropriate to all levels and kinds of education. In addition, it translates such curriculum into textbooks and other teaching materials, and finally, supervises and follows up the execution of a global educational plan once it has been approved by appropriate authorities (CERD, 1978).

Changes in the curriculum are approved by the government, at the proposal of the Ministry of Education which seeks advice from CERD. Once the change is officially approved, it becomes compulsory nationwide, without prior experimentation. Usually no serious effort is made to ensure relevance.

In the state schools, the implementation of the curriculum is ensured by centrally issued directives and by an educational inspectorate. Private schools implement official curricula with some liberty in the details. Curriculum policies at the secondary school level have not been subject to any major changes since 1968 owing to the upheaval caused by the war.

Summary

Education in Lebanon is highly centralized, every aspect of it is planned and administered by the central ministry. There are both private and state schools. Over half of the students attend private institutions which are required to follow the guidelines of the official curriculum.

One important aspect of the system of education in Lebanon is the importance given to the study of languages. Students at all school levels are required to learn at least one language in addition to Arabic. Science courses are among the subjects that are taught in a foreign language. This could be considered a strong aspect of the educational system in Lebanon since a considerable number of Lebanese students continue their further education in foreign countries (mostly English- and French-speaking countries). Those who continue their studies in Lebanon, especially in scientific disciplines must choose between French and English as the formal language of instruction in most universities.

Science curriculum in Lebanon has been subject to several reforms since 1932. The latest one, recommended in 1978, failed to take place because of the war situation. As stated in l'Actualité a number of projects have been planned and implemented in order to rebuild Lebanon and return Beirut to its primary role as the center of finance, business and culture in the Middle East (German, 1996, June 1). The wealth and stability of the country today make it an appropriate time for a curriculum reform in science.

In the next chapter the actual policy for science curriculum in the countries selected for this study will be presented in order to compare them with the policy of Lebanon

Chapter 4 Secondary Science Curriculum Policies in the Selected Developed Countries for General and Advanced Students

The purpose of this chapter is to describe, analyze, and compare curriculum policies in the U.S.A., the U.K. and Japan planned for general and advanced students in science. The first part of this chapter describes curricula for general students: those who will continue their education in arts, who will go to technical schools or who do not continue their education beyond secondary level. The second part of this chapter deals with curricula planned for advanced students: those who will pursue a career in science. The analysis is a qualitative comparison, based mainly on government documents, a literature survey, study and research in the field, and UNESCO work. The Second International Science Study (SISS) carried out under the auspices of the International Association for the Evaluation of Educational Achievement (IEA, 1988), and the International Assessment of Educational Progress (IAEP) studies (1989; 1992) in which the U.S.A., U.K., and Japan have participated, provides basic information used in this analysis. Curriculum policies published in the curriculum guidelines, and in some cases in the national curriculum in each country, will be categorized and analyzed in this chapter.

In every country, science curriculum policies which affect the teaching and learning of science are represented as an interplay of three major elements of central interest to this study. One of the elements is concerned with the pattern of science programs (science subjects offered in schools, the amount of time spent on each science subject, and the content of the school science subjects). The second is concerned with the aims and objectives of science curricula. The third element deals with the organization of school science (the organization of the educational system, the number of school days per school year, science requirements for graduation from high school, teaching strategies, and modes of examinations). These elements are the subjects of policies established by the country's ministry or department of education. Curriculum guidelines contain statements of these policies and represent an important part of the data used to describe science education in the countries selected for comparison in this study.

Structure of the Educational System

The system of education in each country is characterized by specific features that make it unique and which affect the science education policy in each country. For example in the U.S.A., education is essentially decentralized and educational policies are made by each of the 50 states and sometimes by communities within these states. In Japan and the U.K., the system of education is highly centralized in that there is a single uniform curriculum for each subject at each grade level. The introduction of the National Curriculum in the U.K. in 1988 set the curriculum standards for the whole country (DESWO, 1988; The National Curriculum Council, 1989a). This was a major change in the system, in which teachers had previously enjoyed a high level of autonomy. The curriculum standards for elementary and lower secondary schools in Japan are stated in the course of study issued by the Ministry of Education, Science and Culture in Japan (Jacobson, Doran, Humrich, Kojima, Miyake, & Takemura, 1986; Ministry of Education, Science and Culture, 1982). The course of study in these countries provides the basic framework for curricular aims, content, and teaching methods. Two important features of the educational system are worth comparing. These are: the organization of the school system and the organization of the school timetable.

The Organization of the School System

In the U.S.A. about 90% of school-aged children attend public school which is free, while the remainder attend non-public institutions run by religious organizations or private associations (Miller 1986). In the U.K. most children (94%) attend state schools which are free, but some 6% attend private schools (Central Office of Information, 1987). 97% of elementary and lower secondary schools in Japan are public and free (Kazuo, 1990; NIER, 1987).

The minimum requirements for school attendance vary in the three countries. The most common age for starting school is six years in the U.S.A. and Japan, and five years in U.K. In the U.S.A., education is compulsory to age sixteen (and in some states to age 18), that is, ten years of compulsory education (Beauchamp, 1992). Secondary education in the U.K. is compulsory up to the age of sixteen, that is, eleven years of school, and pupils can stay in school voluntarily for up to three years longer (DESWO, 1985; Whitaker's Almanack, 1996). In the academic year 1983-84, about half the population of 16-18 year olds were in school, (DESWO, 1985) and this has increased to around 65% (SCAA, 1995a, 1995b; The Sunday Times, 1993; Whitaker's Almanack, 1996). In Japan, nine years of elementary and lower secondary schools are compulsory (Kazuo, 1990; NIER, 1987). According to Beauchamp (1992), almost 94% of lower secondary graduates go on to the upper secondary schools full-time (three years), while another 2% attend part-time or take correspondence courses (four years). This is summarized in Table 1 below.

Table 1

School Educational Ladder

Number of years spent at each level	U.S.A.	U.K.	Japan
Compulsory			
Age	6-16	5-16	6-15
Years	10	11	9
Primary			
Age	6-11	5-11	6-11
Years	1-6	1-6	1-6
Lower secondary			
Age	12-14	12-16	12-14
Years	7-9	7-11	7-9
Upper secondary			
Age	15-17	17-18/19	15-17
Years	10-12	12-13	10-12
Total Years	12	13	12

Note. In this table, kindergarten is excluded because it is considered by most countries as a part of pre-school education.

The patterns of the school structure vary in the three countries, the most notable variations are the division of the grades into different schools, and the time spent in school. As shown in Table 1, page 75, in the U.S.A. and Japan, the pattern of the educational ladder is 6+3+3, that is 6 years in primary school years, 3 years in lower secondary and 3 years in upper secondary. Other structures are also found in the U.S.A. In the U.K. the pattern is 6+5+2. Secondary education, in the U.K. is divided into two cycles: the first five years, which are known as Forms I through V, and the second cycle, consisting of two years which are termed Lower Form VI and Upper Form VI. The most obvious characteristic of Form VI in the U.K. is specialization. Most students concentrate on two or three subjects, occasionally four, for G.C.E. Advanced–level (A level) examinations (Central Office of Information, 1987, 1988; Education Information Section, 1995). In some parts of the country, the Lower and Upper VI forms are contained in a separate structure called a Sixth Form College. In Japan in 1980 the proportion of upper secondary and university graduates was the highest in the world with only a 5% dropout rate in upper secondary schools and 10% in colleges and universities (Sumeragi, 1980). In 1990, although the number of students dropping out of school increased, it is still considered low (10%) and 90% of students are graduated from upper secondary school (Kazuo, 1990). Today, the number of Japanese youth attending some form of higher education is second only to the United States (Beauchamp, 1992).

In all three countries studied, education is compulsory to age 15 or 16. Most children attend public school and most continue their education beyond the compulsory age. The public school system in each country is responsible for delivering a curriculum for pupils to the age of about 18 years.

The Organization of the School Timetable

The organization of the school also varies in the countries selected for this study. However, in this section, the figures are somewhat misleading. The researcher found substantial confusion about the number of school hours per week and per day and also the number of school days per week. The literature concerning these issues reveals some contradictions among the reports. In order to resolve these contradictions, the researcher decided that it was more legitimate to use only data based on government documents.

In the United States the average school year is 180 days (5 days per week) (Beauchamp, 1992) and the average length of the school day is 6-7 periods. A typical classroom period lasts about 50 minutes (McKnight, Crosswhite, Kifer, Swafford, Travers, & Cooney, 1987; National Science Board, Commission on Precollege Education in Mathematics, Science and Technology, 1983).

In the U.K., the length of the school year is about 200 days (DESWO, 1984). According to a 1987 study, the majority of the schools in the U.K. open for 38 to 40 weeks per year and the average length of the school week is about 27 hours. The school day is normally divided into 8 periods (Keys, 1987). The most common length of a classroom period in British Form I-V secondary schools is 40 minutes. Very few schools have fewer than 32 periods a week, and many have more than 40. Form VI usually has fewer classroom periods per week than in Forms I-V, since more outside study, library time and writing is required (DESWO, 1984).

In Japan the length of the school year is 240 days and students attend schools 6 days per week. A minimum of 210 days of instruction including a half day on Saturday is required (Beauchamp, 1992). This allows 30 "extra" days for field trips, examinations, professional days, and other activities. The average length of the school day is 8 periods, with each one lasting 50 minutes (NSF, 1983; Jacobson, et al, 1986).

Table 2

School Organization (Secondary Level)

	U.S.A. (days)	U.K. (days)	Japan (days)
No: of school days per year	180	200	240
No: of school days per week	5	5	5 1/2
No: of school periods per week	~30-35	40	~34
No: of school periods per day	6 - 7	8	8 (4 on Saturday)
Length of a period (min)	50	40	50
No: of minutes per year	54 000-63 000	64 000	~67 000

Note. ~ = approximately

Table 2, page 78, summarizes the information on the organization of the school at the secondary level in the countries studied.

In the three countries studied, attendance in school varies from 180 days in the U.S.A. to over 210 days in Japan. The number and average length of the school periods also varies among the three countries ranging from 30 to 40 periods per week.

Comparison of the Aims and Objectives in the Selected Developed Countries

The examination of the many statements of aims and objectives for science education in the science guidelines of the countries in this study led the researcher to distinguish two obvious features; first, these statements are diverse; second, many statements while superficially different in form appear to represent similar ideas. This diversity in statements called for a system of classification that would permit identifying general conclusions. For this purpose, six categories of aims and objectives that were derived from the literature, and have been used by many researchers in the field, were identified for this study. These categories of aims and objectives are also a part of the three major domains of Bloom's taxonomy (Bloom, Krathwohl, & Masia, 1984). The categories will be outlined below and an example given of each type of objective from the countries described in this study.

The Cognitive Domain

Three categories of aims and objectives are considered in the cognitive domain. These are: Science Content; Breadth and Balance; and Intellectual Process. These aims and objectives deal with the acquisition of functional information or facts which are organized around a variety of theories, conceptual schema, categorical frameworks and other interpretative principles (Bloom et al, 1984; Armstrong, Cornell, Kramer, & Roberson, 1970; Zais, 1976). They also stress the value of a command of the products of scientific endeavor rather than the process of its development and application (Science Council of Canada, 1984). In these categories also fall the aims and objectives that involve developing the skills of scientists such as the ability to observe, classify, formulate, evaluate, interpret and explain results, and to apply the use of science content and processes in decision (Zais, 1976). Examples in these categories of objectives from the countries studied are:

Science Content: The student should be provided with science courses that are linked with other subjects across the curriculum (DESWO, 1985, 1988; NCC, 1989b).

The student should learn the fundamental concepts of science (California State Board of Education, 1985; NRC, 1996).

Breadth and Balance: The student should be provided with the essential experience of broad and balanced science curricula (DESWO, 1985, 1988; NCC, 1989a, 1989b).

Intellectual Process: The student should be provided with learning techniques that comprise the scientific method, to aid in validating knowledge and to develop thinking skills for life long learning (California State Board of Education, 1985; NRC, 1996).

The Affective Domain

The Nature of Science and The Application of Science are the two categories of aims and objectives that are included in the affective domain. They includes aims which describe changes in interest, attitudes and values, and the development of appreciation and adequate adjustment (Krathwohl, Bloom, Masia, 1964). Aims in this domain also stress the development of the individual, self-respect, respect for others, for life, respect for the environment, beliefs, responsibility, autonomy, intellectual thinking, and self-discipline (Zais, 1976). These aims focus on the interaction between science and society, and also stress the development of creativity, autonomy, cooperation, teamwork, and a sense of responsibility. Examples of objectives that fall in this category are:

Nature of Science: To develop students' ability in and positive attitude toward making inquiries about nature through observations and experiments (Ministry of Education, Science and Culture, 1983b).

Application of Science: Should be aimed at preparing pupils as effectively as possible for adult and working life (DESWO, 1985; NCC, 1989c).

The Psychomotor Domain.

One category of aims and objectives is included in this domain: the Manipulative Skills category. The psychomotor domain concerns itself with the development of physiological, manipulative or motor skills (Bloom et al, 1984; Lorber, 1996). In this category fall the aims and objectives that involve reflex, basic-fundamental and skilled movements; perceptual and physical abilities; and non-discursive communication (Harrow, 1972). An example in this category is:

Manipulative Skills. Full weight must be given to the development of scientific skills and processes as well as to knowledge and understanding (DESWO, 1985, 1988; NCC, 1989b).

It should be noted that the six categories of aims and objectives are inseparable; they complement one another. The learning of facts involves a variety of skills; the learning of any skill takes place within the context of a complex of attitudinal dispositions (Zais, 1976).

The six categories of aims and objectives were used to compare the stated aims and objectives for school science curricula provided by the policies in the countries selected for this study.

An examination of the list of aims and objectives shows that:

1. The aims and objectives mainly revolve around the provision of scientific information, and the development of scientific skills, attitudes, appreciation and interest.

2. Many of the aims listed are common to most of the countries in the study, several share identical statements; some statements on aims and objectives are phrased differently but all incorporate much of what the other groups include.

3. The U.K. gives a list of aims and objectives for each of the primary and lower secondary levels, but does not provide aims and objectives for the upper secondary level (A-level).

4. Japan lists aims and objectives not only for the science syllabi at each level, but also for various individual science subjects at the lower and upper secondary levels.

Table 3, page 84, gives the results of analyzing the aims and objectives of science education at the secondary level in the three countries according to the categories of aims and objectives generated for this study. Table 4, page 85, shows these aims and objectives as a percentage of the total.

Table 3

Classification of the Aims and Objectives in the U.S.A., U.K., and Japan

Objectives		U.S.A.	U.K.	Japan
	Science Content	4	4	1
Cognitive	Breadth and Balance		4	1
Domain	Intellectual Process	4	8	2
Affective	Nature of Science		4	10
Domain	Application to Science	6	9	3
Psychomotor Domain	Manipulative Skills	4	2	3
Total		18	31	20

From the results in Tables 3 and 4, we can state the following about the importance ascribed to each domain:

Aims in the cognitive domain deal with familiarizing students with the elements of scientific knowledge, and understanding scientific concepts. All students should know, understand, and in various ways be able to manipulate the substance of scientific knowledge. Aims also deal with the development of the ability to think scientifically, to develop curiosity, and to apply the knowledge and skills learned in daily life. The aims and objectives of this domain are the second most often encountered in the curriculum guidelines examined for this study. The percentage of aims and objectives in the cognitive domain rank from a low value of 20% in Japan to a high value of 52% in the U.K., with the U.S.A. closer to the U.K. at 45%.

Table 4

The Percentage of the Objectives and Aims in the U.S.A., the U.K., and Japan in Each Category in the Cognitive, Affective and Psychomotor Domains

Objectives	U.S.A.	U.K.	Japan
Cognitive Domain	**44**	**52**	**20**
Science Content	22	13	5
Breadth & Balance	0	13	5
Intellectual Process	22	26	10
Affective Domain	**33**	**42**	**65**
Nature of Science	0	13	50
Application to science	33	29	15
Psychomotor Domain	**22**	**6**	**15**
Manipulative Skills	22	6	15
Total	**99**	**100**	**100**

The aims and objectives of the affective domain are the most common in the curriculum guidelines examined in this study. They deal with assisting students to make an appropriate career choice through the explanation of scientific laws; introducing them to the technological applications and social consequences of science; and helping them to gain a deep understanding of the need to respect nature. The percentage of the aims and objectives in this category are 33% in the U.S.A.; 42% in the U.K.; and 65% in Japan. The large differences in aims and objectives in this domain between Japan and U.S.A. are due mainly to the differences in social, economic and cultural characteristics of each country. For example, Japan has developed as a highly homogeneous society sharing a single monoculture where the needs of the society are dominant over the needs of the individual. Whereas in the U.S.A., which is characterized by a heterogeneous society, the emphasis is on the needs and interest of the individual. This comparison will be of great importance in making suggestions for reforming the objectives of science education in Lebanon, which is also a homogeneous society.

Aims and objectives in the psychomotor domain are least common in the curriculum guidelines in the countries selected for this study. The justification for including objectives in this category at the secondary level is that the development of such skills can enhance the student's ability to "solve problems" in life in general. The percentage of the objectives and aims in these categories in the countries studied is: U.S.A. 22%, U.K. 6%, and Japan 15%.

The data in Table 5, page 87, shows the following characteristics:

Table 5

Countries with the Highest Percentage of Aims and Objectives at Each Category of the Three Domains

Domain	Categories	Country with the highest percentage	
Cognitive	Science content	U.S.A.	22%
	Breadth and balance	U.K.	13%
	Intellectual process	U.K.	26%
Affective	Nature of science	Japan	50%
	Application to science	U.S.A.	33%
Psychomotor	Manipulative skills	U.S.A.	22%

In spite of the common features among the studied countries, some major differences can be observed, as shown in Table 5. Japan puts more emphasis on the affective domain in the Nature of Science category. The U.K. puts most emphasis on both cognitive and psychomotor domains in the Breadth and Balance and Intellectual Process categories. The U.S.A. seems most balanced, with emphasis placed on all three domains in the categories of Scientific Theories, Concepts and Laws; Science Content; Application to Science; and Manipulative Skills.

Despite these differences, the countries studied recognize that the three domains and their sub-categories should be aspects of any science curriculum in which students will: 1) be equipped with a wide range of skills and understanding; 2) be able to apply the acquired knowledge in the world of work; 3) meet national priorities and needs; and 4) develop respect for and a positive attitude to nature. The similarities and differences in aims and objectives for science curricula in the countries studied, while taking into account the characteristics of each country, can be used in reforming the science curriculum in Lebanon.

The three countries consider schools as part of the community, life-style values and culture. They address intensively the intimate relations between the outcomes of schooling and the quality of life in society. The aims and objectives of science education in the three countries focus on mankind, problems and concerns, while stressing the development of mature and responsible citizens capable of flexibility in times of change. Also included is concern about basic skills, academic standards, preparation for career and employment. These issues should be considered in making suggestions for reforming science education and will be addressed in chapter 6 in this study.

Patterns of Science Curriculum

Time Allotted to the Study of Science

Unfortunately, there is little up-to-date information on how much time is devoted to science in U.S. schools. However by referring to work on this issue such as the Second International Science Study (SISS) (IEA, 1988), the International Assessment of Educational Progress reports (IAEP, 1989, 1992), and reports on education policies in the countries studies, it is possible to get a quite accurate estimate of the amount of time allotted to the study of science at all school levels. As part of these reports, all the states reported policies concerning the amount of instruction in science and mathematics. Most states recommended 13% of the time, or 175-225 minutes per week, equal to 4 class periods to be devoted to science classes for grades 7-10 (Blank & Espenshade, 1987).

In the U.K., students study science for 10% of their school time in mixed ability groups in year 1 and 2. Streaming is introduced in year 3 and pupils spend 15% of their time on science. In years 4 and 5, science is optional. However data from GCSE Examination Results produced by the School Curriculum and Assessment Authority (SCAA) (1995a) show that in 1994 and 1995, 21% of 16 years old students sat for a GCSE examination in at least one science subject.

In Japan, according to UNESCO (1986d), and the Ministry of Education, Science and Culture (1982, chart XXVI), the average time allocated for science study, expressed as a percentage of the total time available for all subjects is 8%-10% at elementary level, and 10% at the lower secondary level. Science is taught for 3 periods per week in the seventh and eighth grades, and from 3 to 4 periods per week in the ninth grade (Umeno, 1992).

Tables 6, 7, and 8, pages 90, 91 and 92 present a summary of the time allotted to science in each of the three countries (see also Figure 1 p. 93).

Table 6

Approximate Time Allotment for Science Courses in Periods per Week for the General Student in U.S.A.

School level	School Year	Age	Time Allotment periods	hours	Science Subjects
Secondary	12	17			None or Biology or Physics or Chemistry or Others
	11	16	4	3.3	None or Chemistry or Physics
	10	15	4	3.3	None or Chemistry or Biology
	9	14	4	3.3	Biology
	8	13	4	3.3	Earth Science
	7	12	4	3.3	Integrated or General
Primary	6	11			Elementary School Science
	5	10			Elementary School Science
	4	9			Elementary School Science
	3	8			Elementary School Science
	2	7			Elementary School Science
	1	6			Elementary School Science

Table 7

Approximate Time Allotment for Science Courses in Periods per Week for the General Student in the U.K.

School Level	School Year	Age	Time Allotment periods	hours	Science Subjects
Secondary	13	17			None or Biology or Physics or Chemistry or Others
	12	16			"
	11	15			"
	10	14	6	4	Biology or Physics or Chemistry
	9	13	5.5	3.7	Integrated Science
	8	12	4.5	3	Integrated Science
	7	11			Integrated Science
Primary	6	10			Elementary School Science
	5	9			Elementary School Science
	4	8			Elementary School Science
	3	7			Elementary School Science
	2	6			Elementary School Science
	1	5			Elementary School Science

Table 8

Approximate Time Allotment for Science Courses in Periods per Week for the General Student in Japan

School level	School Year	Age	Time Allotment periods	hours	Science Subjects
Secondary	12	17			None or Biology or Physics or Chemistry or Earth Science or Others
	11	16			"
	10	15	3	2.5	Integrated Science
	9	14	3	3.3	Integrated Science
	8	13	4	3.3	Integrated Science
	7	12	4	3.3	Integrated Science
Primary	6	11			Elementary School Science
	5	10			Elementary School Science
	4	9			Elementary School Science
	3	8			Elementary School Science
	2	7			Elementary School Science
	1	6			Elementary School Science

The tables above show the approximate amount of time given to science per week and per school year in high school (see also Table 2, p. 78). It is important to mention that for the United States the time allotted for science at the upper secondary level can be calculated by taking into account the fact that two science courses are required in most States. The first required course is taken in grade 10 and the second in grade 11 or 12 (Jacobson, et al, 1986).

Figure 1 below compares the total time devoted to science at the secondary level in the three studied countries.

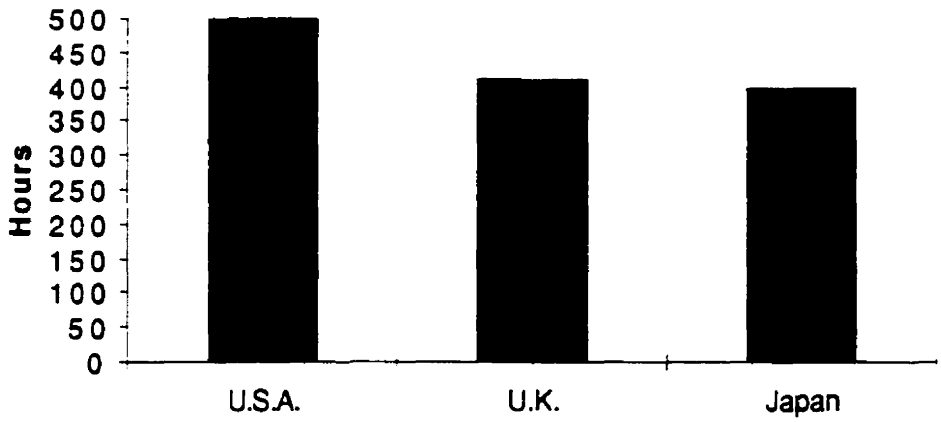


Figure 1. Total Time Allotted to the Study of Science at Both Lower and Upper Secondary Level

In order to get a better picture of the time allowed for compulsory science courses at lower and upper secondary levels in relation to the total time allowed for all school subjects, it was essential to calculate the percentage of time spent on science at each level. This was done by calculating the percentage from means for each country. The mean at each level was calculated by dividing the total class periods at each level by the number of years in which science is a requirement at that level.

Table 9, page 94, shows the findings obtained. From Figure 1 and Table 9, it appears that at the lower secondary level, the U.S.A. and the U.K. have the highest number of periods and percentages of time allowed for science, followed by Japan. The U.S.A. is rated first at the upper secondary levels followed by Japan. Since science is not a compulsory subject at the upper secondary level in the U.K. the percentage is reported as zero.

Table 9

The Mean and Percentage of Compulsory Science in Relation to the Total Time in the School Time Table for Lower and Upper Secondary Levels.

	Grade 7-9		Grade 10-11	
Country	Mean # of periods/week	Percentage	Mean # of periods/week	Percentage
U.S.A.	4	13%	3	9%
U.K.	5	13%		
Japan	4	10%	1	3%

<u>Science Courses Offered</u>

In all three countries a course in integrated sciences is the favored course in the first two years of secondary school. Indeed in Japan, the curriculum remains integrated as far as grade 10. In grade 7 to 10, two science courses are taken: physical sciences and combined biology and geology course. Japan is a notable exception in this preference (Ministry of Education Science and Culture, 1983a, 1989a). Science is integrated only up to grade 7 in the U.S.A. and grade 8 in the U.K.

Because of the great variety among American schools, it is more difficult to describe a national program of science education in the U.S.A. However, Figure 2, Appendix A (page 219) shows two generalized patterns of

American science programs (Jacobson, 1986; Miller, 1986; National Academy of Sciences, 1990), used for this study and considered for comparison with the other selected countries.

At the lower secondary level (grade 7-9), courses in general science, physical science, earth science, and biological science are often offered. At the upper secondary level, the science curriculum is usually a full year sequence in one branch of science. Most often, the science course offered is physics at grade 12, but many schools also include a second year of biology or chemistry. According to the National Academy of Sciences (1990), about 75% to 80% of high school students take a course in biology, usually in the ninth or tenth grade. Since many states require no more than 2 years of upper secondary science credit for graduation, the numbers of students enrolled in science courses at grade 12 are much fewer than in the other grades (around 20%) (IEA, 1988; National Science Board, 1993; NIER, 1986; Weiss 1994).

In the U.K., it is generally accepted that a broad science education should involve more than the traditional subjects; biology, chemistry and physics. Many schools are introducing subjects such as astronomy, environmental science, earth science and Science and Technology in Society (STS). Students are encouraged to explore the social, economic and political aspects of science. A balanced science education in which all aspects of science are equally represented is offered in the U.K. in the form of integrated, or combined sciences (DESWO, 1988; NCC, 1989b; Science Education Newsletter No 61, 1985).

Therefore, in a large number of secondary schools in the U.K., all pupils follow the same integrated science courses for the first two years of secondary school and are then given an introduction to the separate sciences in year 3. During year 3, pupils choose the option they will follow during years 4 and 5, which lead to public examination, the GCSE (DESWO, 1988; Science Education Newsletter No 66, 1986).

We can conclude that, at the secondary level, science is offered in a variety of ways in the three countries: a) in integrated, combined or modular science such as physics with biology, physics with chemistry, physical science with biology followed by three sciences: physics, chemistry and biology; b) as separate courses in biology, chemistry, physics and earth science; c) non-traditional science subjects such as astronomy.

Figure 3, page 97, presents the science subjects offered in both lower and upper secondary level in the countries included in this study. It will be seen that general students do not take science at the upper secondary level

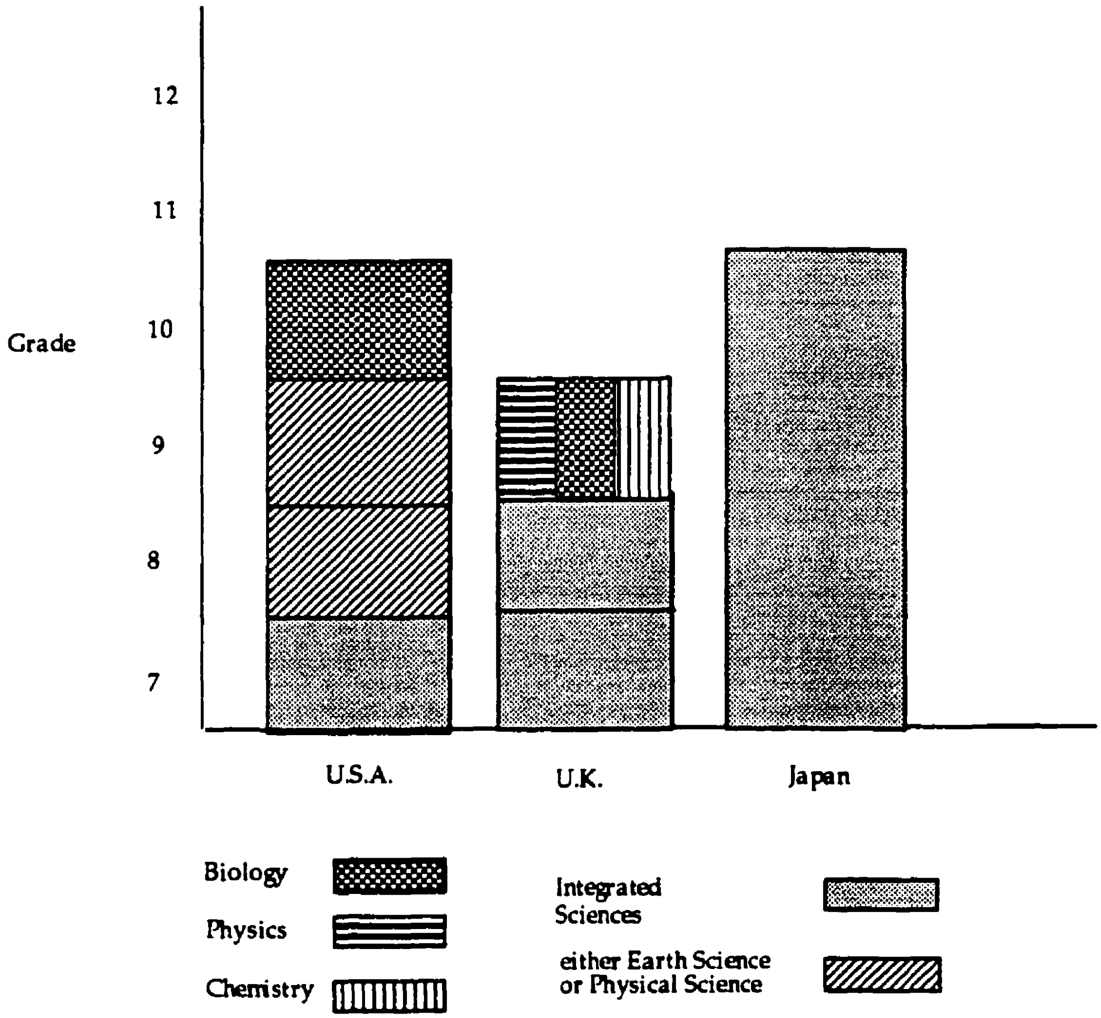


Figure 3. Science Subjects Offered at Both Lower and Upper Secondary Levels for the General Students.

The Content and Structure of the Science Courses Offered at Secondary Level

In this section science content is reviewed briefly in each country. Appendix B (page 220-226) presents the content of science courses in detail at each level for the U.S.A., U.K. and Japan.

Science content in the U.S.A.

American secondary science education is unique in the diversity of programs offered to students. Programs vary widely in content, purpose and articulation in different jurisdictions.

Analyzing the content of science courses in the U.S.A. posed a dilemma. Information was hard to get and sometimes non-existent, due to the fact that education in the U.S.A. is decentralized and diversified. Content of science courses is left to the discretion of the classroom teacher or the head of the department within an individual school. The method used to collect information about the content of science for this study was based mainly on the examination of the published material of well-recognized programs (such as SCIS, SAPA, BSCS, and Project Physics), published state guidelines (California State Board of Education, 1985; New York State Education Department, 1984), national research studies on the status of science education such as Project 2061 (AAAS, 1993) and the National Science Education Standards (NSTA, 1995; NRC, 1996), the IEA study (IEA, 1988; Miller, 1986), and IAEP study (1992).

In junior high school at grade 7 the most commonly offered science course is life science, At the grade 8 level, most schools offer a course in earth and space science. During grade 9, the last year of junior high school, physical science is the most commonly offered course.

The content of school science at the lower secondary school is the following.

Table 10

The Content of Science at the Lower Secondary Level in U.S.A.

Grade 7	Life Science	a collection of topics dealing with biology (cell structure and function, and organs and system), personal health, ecology and conservation, and transformations of energy.
Grade 8	Earth and Space	a combination of astronomy including the solar system, space exploration, and recent discoveries in space, meteorology, oceanography, forms and transformations of energy, and motions and forces.
Grade 9	Physical Science	the topics most often included are environmental science, structure of matter, energy transformations, history and philosophy of science, geology, astronomy, and physics.

The three courses described above are discipline-centered science courses. Their content shows that various science subjects have been integrated. Therefore, the junior high school science courses are often structured in modular units and cover a wide range of material.

At the senior high school level two courses in science are normally compulsory for general students and these courses are offered in grades 10 and 11. Biology seems to be the most frequently offered science course at grade 10 level.

The content of upper secondary school science is the following:

Table 11

The Content of Science at the Upper Secondary Level in U.S.A.

Grade 10	Biology	cell structure and function; genetics, and biological evolution; metabolism, behavior; reproduction and development of plants and animals; matter, energy, and organization in living systems; personal health and nutrition.
Grade 11	Physical Science	a combination of topics from subjects such as chemistry, physics, earth science, and astronomy.

<u>Science content in the U.K.</u>

The National Curriculum introduced into schools in the U.K. in Autumn, 1989 was planned for pupils of compulsory school age (5-16) (DESWO, 1988). The National Curriculum in science includes 2 key aspects, or profile components: "exploration of science", which emphasizes the skills and strategies of science; and "knowledge and understanding", which emphasizes the conceptual understanding that enables pupils to use their skills to explore, investigate, experiment, and solve problems. It is intended that the two aspects of science should be experienced and understood interactively by pupils. Each of these profile components is broken down into attainment targets. There is a single attainment target in the first profile component. The other targets are in the second component. Attainment targets are defined as "the knowledge, skills, and understanding which pupils of different abilities and maturities are expected to have achieved in each subject area" (DESWO, 1988, p. i).

There are a number of attainment targets specified for each school level. The programs accompanying the attainment targets at each key stage outline the experiences and types of activities which should be provided for children in science. There are 10 levels of attainment within each attainment target (NCC, 1989b). The attainment targets specified for each level can be organized to produce four different combinations. Appendix C (page 227) shows the possible models.

As was shown in Figure 3, page 97, the most common pattern in the U.K. is a balanced science course in combined or integrated science (in grade 7 and 8) followed by a separation into physics, chemistry, biology, and in some cases earth science (in grade 9). It is noteworthy that in grade 8, the integrated science course is intended to prepare students for further studies in science by emphasizing an understanding of the processes by which scientists advance the knowledge of science, and the process by which science is utilized in society. This objective is not apparent from the summary table, and is not an objective in any other curriculum described.

The content of school science at the lower secondary school is the following:

Table 12

The Content of Science at the Lower Secondary Level in U.K.

Grade 7	Integrated Science	an historical development of scientific principles and theories; a simple introduction to astronomy, earth science and microbiology; environmental science; the study of magnetism and electricity; and methods and processes of science.
Grade 8	Integrated Science	water; metal and alloys; light; classification; and the study of invertebrates.
Grade 9	Physics ; Chemistry; Biology; Earth Science;	topics in physics; chemistry; biology; earth science; and weather and climate

Science content in Japan.

In Japan, the lower secondary school science syllabus includes two major "fields". The first field includes physics and chemistry while the second field includes biological and earth sciences (Ministry of Education, Science and Culture, 1983a, 1989a; Nogami, et al, 1987).

The content of school science at the lower secondary school is the following:

Table 13

The Content of Science at the Lower Secondary Level in Japan

Grade 7	Field 1:	substances and their reactions; force, substances and atoms
	Field 2:	kinds of living things and their life; motion of the earth
Grade 8	Field 1	electrical current
	Field 2	construction of bodies of living things; changes in weather
Grade 9	Field 1	substances and ions; motion and energy
	Field 2	mutual relationship between living things; the earth's crust and its changes; human beings and nature

At the upper secondary level "Science I", an integrated course, is required at grade 10. Its topics are selected from physics, chemistry, biology, earth science, matter and energy (Nishikawa & Kobayashi, 1986). The content of Science I is force and energy; composition and change of substance; evolution; the balance of the natural world; and human beings and nature (Ministry of Education, Science and Culture, 1983a, 1989a; Umeno, 1992).

In summary, an examination of the content in the three countries shows the following:

1. There is a remarkable level of agreement among the three countries on developing a positive attitude toward living things and the natural environment. In Japan, topics that stress the attitude and values of science,

for example energy, human beings and nature, receive greater emphasis in their science content than in the other countries.

2. In the three countries there appears to be great emphasis on science content that includes the following topics: a) earth science and astronomy: the solar system, explanation and discoveries in space; meteorology; and principles of astronomy; b) Physics: magnetism, electricity and electro-magnetism, mechanics and dynamics (force and motion), and electrodynamics; c) chemistry: structure and function of the atom, and chemical reaction; d) biology: ecology and conservation; personal health such as food, diet, disease, drugs, narcotics, and alcohol abuse; concept of cell structure and function; reproduction; molecular biology such as gene and inherited disease; and evolution.

3. The science content in the three countries studied, especially in the U.K, emphasizes intellectual processes and manipulative skills in science topics. These topics are: a) methods and process of science based on the interaction of science with society; and b) the practical application to science and its implication such as agriculture, industries, and business

Science Requirement for Graduation (Grade 10-12)

Science is a required subject at the secondary school level in all the countries studied. However the number of science courses required for graduation (grade 10-12) varies from one country to another.

Since 1983 in the U.S.A., most states have moved toward increasing high school graduation requirements in science. In the fall of 1989, most states required that before receiving a high school diploma, every student must have completed at least two years of science including biological and physical science. In some states science requirement included a laboratory component (Jacobson, 1986; Miller, 1986; NSTA, 1995). In Japan one science course is required for graduation and in the U.K., science is not a compulsory subject at the upper secondary level. Table 14 below shows the science courses required for graduation in grades 10 to 12.

Table 14

Number of Science Courses Required for Graduation Grade 10-12

	Countries		
Science Courses	U.S.A.	U.K.	Japan
Biology	1		
Integrated Science			1
Other[a]	1		
Total	2		1

Note: [a] such as physical science; earth science, life science, astronomy.

Science Subjects and Content for Advanced Students in Science

The previous section described the science subjects and their content planned for the general student. This section will present the same issues for advanced students in science. In this study, advanced students in science are those who expect to deepen their knowledge in science and to continue their further education in scientific disciplines, in contrast to general students who would be oriented into non-science disciplines, or who would not continue beyond the minimum requirements for graduation from secondary school. Appendix D (p. 228-231) presents in detail the content of science courses planned for advanced student in science at each level for the U.S.A., U.K. and Japan.

Advanced students in science in the three countries selected for this study are offered a variety of science subjects in curricula designed to meet their needs and interests. Students in the U.S.A. who want to pursue a career in science are offered four years of progressively advanced instruction in science, including biology, physics, chemistry, advanced physical science, advanced biology, science laboratory courses and specific science modules. In some schools more diverse courses, such as human biology, astronomy, physiology, chemistry II, physics II, botany are offered (Cooper, 1983). Science courses are often structured in modular units. Students may elect to take up to 3 or more courses in science in the upper secondary level. More than 50% of American students take two or more years of science and more than 20% take three or more years at the upper secondary level (Cooper, 1983; National Science Board, 1993).

There is little up-to-date information on the content of science courses, therefore, discussing the content of science courses is a difficult task. Courses for each state vary and include subjects in various combinations. However some of the science textbooks used at the upper secondary level, as well as the review of some literature in this domain (AAAS, 1993; Jacobson, 1986; NSTA, 1995; NRC, 1996) offer some help in describing the possible courses.

Biology courses emphasize an ecological approach, biogenetics, biomedical science, the human body and reproduction, and molecular biology. Physics courses offered at the upper secondary level in the U.S.A. concentrate on a historical and philosophical approach (AAAS, 1993; Jacobson, 1986; NSTA, 1995). Some physics courses include applied science topics such as: spaceship earth, using the environment, energy and our future. Also a host of energy-related issues evolve into separate courses or become part of a physics course. Finally almost all physics courses emphasize the study of magnetism and nuclear activity (Miller, 1986; AAAS, 1993). The emphasis in the earth science courses is mainly on stellar radiation and evolution of stars, plate tectonics, geochemical cycles, and space exploration and discoveries. For chemistry courses, the focus is on the nature of chemistry, the structure and electrical nature of the atom (chemical bond, structure and properties of matter) and the dynamics of chemistry.

The arrangements in the last two years of compulsory schooling in the U.K. vary within and between schools. As a consequence, a range of possibilities exists. Some pupils discontinue science while many others take a narrow course in only one of three sciences, while some take three sciences, in which case, the proportion of teaching time allocated to science may be as high as 30%, or 12 periods per week (DESWO, 1988). In 1982, 11.5% of students were enrolled in three science courses (biology, physics, and chemistry) in years four (grade 10) and five (grade 11), 20.5% enrolled in two science courses (biology and chemistry; biology and physics; chemistry and physics), 33% enrolled in one science subject (biology, physics or chemistry), 24% enrolled in one of the other science subjects, and only 10.5% were not enrolled in any science at this level (HMSO, 1982). The SCAA reports examination results for 1995 show that 18% of A (Advanced level) and AS (Advanced Subsidiary) students sat for these two levels of examinations in science (SCAA, 1995b).

The content for science subjects in the U.K. as proposed by the Secretary of State for year four (grade 10) and five (grade 11) is as follows: the variety of life; processes of life; genetics and evolution; human influences on the earth; types and uses of materials; making new materials; explaining how materials behave; earth and atmosphere; forces; electricity and magnetism; energy transfer; information transfer; energy resources; sound and music; using light; the earth in space (DESWO, 1988).

The above topics can be organized into scientific subjects which fall under the following headings: biology; physics; chemistry; integrated science; earth sciences, biological or physical science, and so on. It is left to the school and teacher to decide which combination and science subjects will be offered. However the Secretary of State has suggested models for combining these attainment targets. Appendix C (page 227) shows possible models for these topics.

At A-level students can specialize in one or more science subjects. One can find all traditional and non-traditional science subjects in a wide variety of possible topic combinations. However, according to Keys (1987) and SCAA examination result (1995b), at A-level, relatively few British students (around 5%) study earth sciences or any science subjects other than biology (9%), chemistry (7%) and physics (5%). The content of A-level science courses varies from one school to another, and it remains for the teacher to organize the content from a broad range of suggested topics. Students can choose one or more science subjects from a wide variety of science disciplines in order to continue their specialization.

In Japan the new revision which should have been put into practice beginning in 1993, makes it possible for pupils to select some subjects according to their abilities, needs, and preferences. In this new revision, students are offered an optional science course at grade 9 (Ministry of Education, Science and Culture, 1989a; Umeno, 1992) at the upper secondary level, students can choose the traditional science disciplines such as biology, chemistry, physics, and earth science or continue with Science II. In the new revised curriculum, it appears that students at the upper secondary level are offered 13 science subjects such as physics IA, IB and II, chemistry IA, IB and II, biology IA, IB and II, earth science IA, IB and II, and integrated science, although detailed information is difficult to obtain. These courses also emphasize the relationship between science and human life as well as the applications of science. Other courses such as integrated science aim to help students understand nature (Ministry of Education, Science and Culture, 1989b; Umeno, 1992). Although the science courses are electives, almost all students take at least one elective course in the upper grades. Most Japanese high school graduates have completed courses in the natural sciences, some aspects of which have been based on U.S. curricula and adapted to Japanese needs (Jacobson et al, 1986).

In Science II, the acquisition of science process skills is stressed. Students are also required to study the methods of science. This is unique in the history of upper secondary science education in Japan. The content of Science II consists of observations of specific matter and phenomena; surveys of the natural environment; and studies of historical cases in science (Ministry of Education, Science and Culture, 1982). Each student enrolled in Science II must select appropriate topics independently in order to acquire an interest in nature and the ability to solve scientific problems (Direction générale de l'information, Ministère des affaires étrangères, Japon, 1979; UNESCO, 1984).

Unlike Science II, the other elective science courses in Japan have a fixed course of study. The physics course includes force and motion; wave motion; electricity and magnetism; and atoms. The chemistry course includes topics on chemical properties of substances; states of matter; chemical reactions; and the structure of matter. The biology course includes the formation of a bio-organism; living bodies and energy; homeostasis and regulation; and biotic communities. Finally, earth science includes the structure and history of the earth; and the universe (Ministry of Education, Science and Culture, 1983b, 1989b).

A perusal of the course outlines in Japan indicates that courses are elective and general in nature. The courses appear to cover the well-known traditional topics associated with these sciences. The majority of students in the upper secondary level are enrolled in the chemistry courses offered in grades 11 and 12 (84%) followed by biology (50%), and physics (49%). Only 17% of students choose earth science, and almost no students take Science II (Jacobson, 1986 et al). Secondary school physics and chemistry are widely studied in Japan, whereas biology and earth science attract few students.
In the U.S.A., the U.K. and Japan, students start to select science courses at the beginning of grade 8 or 9. Table 15, page 112, shows the pattern of science courses offered for advanced students in science in the three countries.

All the above would seem to indicate that there is a range of science courses offered in the U.S.A., U.K. and Japan. Traditional and nontraditional subjects are found in the U.S.A. and U.K. whereas, in Japan traditional science disciplines are mostly offered. In the three countries, there are science courses for all abilities, interests and needs with an emphasis on the acquisition of science process and skills.

Table 15

Science Subjects Offered for Advanced Student in Science

Science Subjects	U.S.A.	U.K.	Japan
Biology	X	X	X
Chemistry	X	X	X
Physics	X	X	X
Earth science	X	X	X
Integrated science	X	X	X
Modular or combined science	X	X	
Applied science	X	X	
Others [a]	X	X	

Note: [a] such as physical science; earth science, life science, astronomy.

Teaching Strategies

The terms teaching strategies and learning experiences are used interchangeably in this section reflecting the usage common in the modern literature. The data from the literature show that the different teaching strategies fall into four categories: a) instructional strategies, which are defined as those "Strategies in which the teacher has direct control..." (Hofwolt, 1986, p. 46); b) instructional materials/equipment (enhancement); c) instructional activities (in-class); and d) instructional assignments (out of class) (Center for Vocational Education, 1977). Instructional activities and instructional assignments are "'Student-centered' instruction which allow students to play a more active or self-guided role" (Hofwolt, 1986, p.46).

In the United States a policy statement (AAAS, 1993; Brinckerhoff et al. 1987; Miller, 1986) concerning teaching strategies emphasizes active student involvement with materials, fellow students, the environment, and other resources. In an atmosphere of inquiry, the teacher becomes a facilitator who guides the students' investigations, rather than a disseminator of information. Textbooks are only one resource from which students may draw information. Laboratory investigations promote hypothesizing, stimulate individual interests, and strengthen concept development. The policy statement also suggests that strategies of teaching be based on the active involvement of students in their learning in order to develop scientific skills. These skills will help them to rely on their own inventiveness, curiosity, and talents to attain concepts (AAAS, 1993; Brinckerhoff, et al, 1987; Miller, 1986).

Science education in the secondary schools in the United States is characterized by the following teaching and learning practices:

1. Scientific investigation where students become more systematic and sophisticated in conducting their investigations (AAAS, 1993).
2. "Hands-on" or manipulative materials (AAAS, 1993; Miller, 1986).
3. Class lecture and discussion (Miller, 1986).
4. Alternative activities such as library work, student projects, field-trips, and guest speakers (AAAS, 1993; Miller, 1986).

5. Extensive use of audio-visual materials and demonstration such as: films, filmstrips, film loops, slides, tapes, and records, calculators, television (Miller, 1986), computers, and other technological developments (AAAS, 1993)
6. Class discussion which allows students to present their views, thereby presenting opportunity for students to increase their creativity (AAAS, 1993; Brinckerhoff, et al, 1987).

Science in the U.K. is taught at all stages in a way which emphasizes practical, investigative and problem solving activity. Teaching is also supposed to be related closely to everyday and industrial applications of science. The policy statement suggests a variety of teaching methods and strategies :

1. Problem-solving, investigation, practical work, exposition, discussion, consolidation and practice (The Sunday Times, 1993; Science Education Newsletter No 61, 1985).
2. Teaching methods linked to the community and stressing the discussion of the social implications (DESWO, 1988; Science Education Newsletter No 61, 1985).
3. The use of the child-centered approach with emphasis on finding out and using the knowledge and understanding that children already possess about science. All secondary teachers are encouraged to provide materials that complement rather limit the learners' experiences (DESWO, 1988; NCC, 1989b).

4. Emphasis on practical experiences to build up, develop and extend pupils' ability to think scientifically so that science becomes part of their total conceptual framework rather than a subject that only has relevance in the confines of the school laboratory. (DESWO, 1988; Science Education Newsletter No 78, 1988).

The teaching strategy in Japan is characterized by the following:

1. Emphasis on scientific experiments, which are the application of the content studied as well as experiments related to students' daily lives, should be conducted (Jacobson, 1986; Umeno, 1992).
2. Scientific activities that help students to develop their abilities and aptitudes.
3. Well-planned projects that make extensive use of the school library, and teaching materials.
4. Good human relationships between teachers and students and among students themselves to make student guidance effective (Ministry of Education, Science, and Culture 1983a, 1989a).
5. Field trips, laboratory work, group projects, and classroom activities using science methods (Miller, 1986).
6. Open-ended and inquiry methods (Jacobson, 1986).
7. Imitation and rote learning (Cooper, 1983) (Ministry of Education, Science, and Culture 1983a, 1989a; Nogami, et al , 1987).

Table 16

Teaching Strategies

	U.S.A.	U.K.	Japan
Instructional Strategies			
a) Lecture	X	X	X
b) Discussion	X	X	X
c) Guest Speaker	X		
d) Field Trip	X	X	X
Instructional Materials/ Equipment			
a) Audio-Visual	X	X	X
b) Textbook	X	X	X
c) Computers	X	X	X
Instructional Activities			
a) Role Playing		X	
b) Puzzles			
c) Roundtable Discussion			
d) Simulation			
e) Problem-Solving		X	X
f) Experiments or Laboratory	X	X	X
g) Debates			
h) Exposition			X
Instructional Assignments			
a) Reports	X		
b) Surveys			
c) Problem-Solving	X	X	
d) Experiments	X		
e) Interviews			
f) Research Paper	X	X	X
g) T.V. Programs			
h) Summer Assignment			X

Summer assignments form an important instructional component in Japanese science curricula. Each student is given an assignment in science for the summer holiday months. This is then assessed, considered, and discussed by and with the responsible teacher. This is believed to keep students from forgetting some of what they have learned previously (Jacobson, et al, 1986). These recommended teaching strategies in the three countries are summarized in Table 16, page 116.

Nature of Practical Work Prescribed

In secondary school, science courses in each of the three countries included in this study view practical work as a very important component and as such allocate sufficient time to permit students to conduct their own experiments.

The primary purpose of laboratory work in the U.S.A. is to provide students with direct experience in dealing with problems that are realities in the human enterprise and in the natural environment. The students are able to work on problems as participant observers or to investigate a problem by experimentation using possible alternative procedures for resolving the situation. Experiments undertaken by students often focus on the inquiry nature of science. It is believed to be essential that students develop abilities for studying, learning and shaping the future if scientific problems are to be resolved through student investigation (AAAS, 1989b; California State Board of Education, 1985; New York State Education Department, 1984).

In the U.S.A., laboratory skills and processes are stressed in science curricula at both the lower and upper secondary school levels. Problem-solving, measuring, and graphing skills are integral to successful performance in the topics contained in the science curriculum. The state guidelines generally require a block of instructional time in student-centered laboratory work; at least one or two periods of laboratory work per week are recommended for experimental activity (Jacobson, 1986; Miller, 1986).

Laboratory facilities for science are usually provided starting from the lower secondary level. Most students are taught science in rooms containing "portable science materials". At the upper secondary level, students taking science are taught in special laboratory rooms for science instruction and to some extent their learning is based on some aspects of laboratory work or projects incorporated in their coursework (Miller, 1986).

In the Second International Science Study (IEA, 1988), the U.S. respondents reported that considerable space in their schools is equipped for science teaching and/or student laboratory work. The bulk of the U.S. respondents reported that their science rooms are used more than 80% of the week for science lessons or laboratory work.

Practical work in the U.K. is highly regarded and stressed in the teaching of both traditional and non-traditional science courses. True experimentation and discovery are encouraged at the secondary level. Among practical skills, the processes of science, such as observation and measurement, are also emphasized (DESWO, 1988).

In the policy document, Science 5-16 (DESWO, 1985) it was clearly stated that priority in the curriculum should be given to the processes of scientific thinking such as observing, pattern seeking and experimenting.

Practical work in Japan is also stressed in the teaching of all science subjects. It is considered to be an important element of the science curriculum. Therefore, the course of study of the lower and upper secondary school emphasizes the use of practical activities in teaching science subjects. It also provides the teachers with some suggestions on the kinds of activities believed suitable for teaching the content of the science topics stated in the course of study. The Ministry of Education, Science and Culture provides the school with laboratory equipment and instructional aids which are complementary tools for teaching science. These are slide and overhead projectors, motion picture projectors, VCRs, television and charts.

It has been reported that Japan makes extensive use in its science curricula of educational materials that originated in the U.S.A. including new physics, chemistry and biology materials that were developed by the N.S.F. For example, materials from one such program, the Physics Science Study Committee (P.S.S.C.), were imported by the Physics Education Society in Japan which conducted seminars with participating U.S. specialists, and adapted the P.S.S.C. laboratory equipment to Japanese needs (Cooper, 1983).

It is clear that practical work is widely accepted as an important ingredient of science teaching. In all the countries studied, emphasis is placed on experimentation, observation, and inquiry into nature. Effective utilization of the local environment is also stressed. Students are encouraged to have direct experience with natural phenomena. It is apparent that practical activities can provide a context for students to develop process skills. As national studies have shown (IEA, 1988), practical activities are associated positively with students' science achievement, and with their attitudes towards science.

All the above seems to indicate that the method of teaching emphasized in the countries studied is based on the use of instructional materials such as textbooks, audio-visual aids, practical work, projects and field trips to industries and nature centers. There is also stress on the problem-solving and inquiry approach. It is a unique feature of Japan to allocate summer assignments as part of the curriculum. Laboratory work is viewed in the countries studied as essential in learning science and plays an important role in science education.

Examinations

Uniform terminal examinations in the U.S.A. are not mandated nationwide. Most states have minimum competency examinations administered to public school children at designated grades in K-12. Most states use these examinations as one criterion for high school graduation (Jacobson, et al, 1986). However, more recently, a testing requirement in science for high school graduation is taking place in most states at the end of grade 9 and 10, or 11 (Blank, et al, 1987).

As there are no national examinations, the schools and teachers have the major responsibility for developing an appropriate assessment plan. The information collected with the SISS Teacher Questionnaire (IEA, 1988) showed that at all secondary levels, teachers reported that they rarely or never used standardized tests produced outside the school. The most common assessment procedure was teacher-made objective (short answer) tests, and in some cases, teacher-made essay tests (requiring at least one paragraph of writing). They also used homework assignments, laboratory exercises, and projects in assessing the work of their science students (Miller, 1986).

In the U.K. progress in science is assessed both within the school and by public examinations, in ways which recognize the importance of the skills and processes of science as well as those which reward the ability to reproduce and apply scientific knowledge. These measures allow the pupils to show what they can do rather than what they can not do (McCall, & Wilcox, 1985). It is strongly advised that science education should be presented and assessed in a way that allows the pupils to see its direct relevance to their lives and it should draw on the environment and experience of the pupils themselves (NCC, 1989d; The Sunday Times, 1993).

Successful completion of secondary school in U.K. is linked to performance on external examinations. The main external examinations for secondary school pupils are the General Certificate of Secondary Education

Examination (GCSE) at age 16, and A (Advanced) level at age 18. At the completion of the 5th year of secondary school, a student can take the GCSE in one or more science subjects in addition to other subjects. Pupils are able, with the guidance of their teachers, to choose how many and which subjects to take for the GCSE. The examinations do not cover merely the work of the last term or the last year; instead, each test covers the entire syllabus. Thus, a subject passed at GCSE level represents achievement in the subject over an entire secondary program. Science subjects test skills and knowledge equally, and require candidates to demonstrate laboratory skills along with answering questions and writing essays on scientific subjects (DESWO, 1988; Education Information Section, 1995; NCC, 1989d).

The GCSE examinations cover the entire syllabus (DESWO, 1988; Education Information Section, 1995). The examinations are designed to demand more of able candidates than of less able candidates and to award grades accordingly. Within each subject there is a choice of papers or questions, which will give candidates of all abilities the opportunity to show what they understand, know and can do.

The Sixth Form may be regarded as pre-university training during which students are expected to begin specialization in subjects that they will later study for degrees (Education Information Section, 1995; Keys, 1986). Admission is based upon success in the GCSE. AS (Advanced Subsidiary) level is a single-subject examination, normally taken over two years alongside A-levels, occupying about half the teaching and private study time of A-level. The first courses began in 1987, and the first examinations were held in 1989. Students take AS exams in one, or occasionally two, science subjects at the completion of the first year of Form VI.

Examinations for the GCSE and Advanced level examinations are tests in individual subjects that are provided for students completing secondary (Form V) and pre-university (Form VI) studies. Success in the examinations is the basic requirement for entry into higher education or professional training, as stated in entrance requirements for universities, polytechnics, and other educational institutions, and also for entry into training controlled by the professional associations.

Students in Japan, after graduating from lower and upper secondary schools, have to sit an entrance examination for further study. Entrants' admission to the upper secondary school is based mainly on records of the entrance examination. External testing marks the transition from lower to upper secondary level, and from upper secondary level to college and university (White, 1986).

Entrance examinations in Japan are believed to be an important aspect of Japanese education. It is very important for Japanese students to do well on the entrance examination in order to be admitted to a prestigious upper secondary school and from there into a top university, which can lead to a good position in business or government after graduation. For this reason Juku schools and tutoring services have been developed and become an important industry providing supplementary science education for a large fraction of Japanese students (Nogami et al, 1987). Their primary aim is to give students a competitive edge when taking the critical examinations and to improve their science achievement scores. The number of students enrolling in these programs has increased dramatically recently (Beauchamp, 1992). Almost all Juku are small, taught by well-educated housewives and/or university students but large Juku can be found in major cities. These are staffed by professional teachers who teach from specially prepared textbooks (Beauchamp, 1992; Miller, 1986; Nogami et al, 1987).

Table 17 shows a summary of student assessment in the studied countries.

Table 17

Methods Used for Student Evaluation or Assessment

	Grades		
Type of examination	U.S.A.	U.K.	Japan
Within school (Internal)	9, 10 or 11	All	9, 10 and 11
Public Examination (External)	9, and 12	11, and 12 or 13	9, and 12

Summary

In each of the three countries there is a strong national commitment to quality science instruction as an essential part of the pre-college educational process for both the general population and for students proposing to pursue science-related careers. The result is a work force which, at all levels, has a relatively high degree of science skills. This has been a factor in the very rapid expansion of technical industry in the U.S., U.K., and Japan.

In collecting the data for analysis from different sources in the different countries selected for this study, some difficulties became apparent. The first area of difficulty encountered was in dealing with the amount of time devoted to science subjects. There are differences that exist between what is often called school "hours" and the actual hours of the day. The duration of a lesson may be anywhere from 30 minutes to 50 minutes or more, but schools especially in the U.S.A. speak of them as "hour". In analyzing the data, it was not always clear if school hours or hours of the day had been entered. There could, therefore, be some errors in analysis inherent in this study. The analysis shows that, at the least, there is a commitment to regularly scheduled science teaching, and the time allocation can be approximated.

Another area of difficulty in presenting the facts concerns the time allotted to the study of science for advanced science students in grades 10, 11, and 12. Difficulties arose for the following reasons: In the first place, these years are not always compulsory, in fact, they form an extension to compulsory schooling in most systems. In the second place, the last three years are when specialization begins in most school systems. During these years, a choice of subjects is frequently permitted. Some pupils opt for science subjects, and for them the time allotted to science is considerable. Some pupils choose languages, or humanities subjects. They may drop science altogether or they may be required to follow a curtailed or general course in science. For these reasons the presentation of the time allotted to science during grades 10, 11, and 12 proved difficult and therefore, it was omitted from this study. Again, it can be safely said that each of the three countries provides the opportunity for intensive study in science in the specialization year, up to a maximum of three or four years.

The pattern of science in the countries studied shows that science is a compulsory subject in the first three years of secondary education (up to grade 9). It remains compulsory up to grade 10 in Japan, and grade 11 in the U.S.A. In all the countries studied, secondary school science starts with an integrated science program. Japan extends integrated science through lower secondary and the first year of upper secondary level. Separate courses in physical and earth science are only offered in the U.S.A. and the U.K. at this level. A unique feature in the U.S.A. is that a different science is studied each year. A common pattern in the U.S.A. is to have earth science in the 9th grade, biology in the 10th grade, chemistry in the 11th grade and physics in the 12th grade. In all the other countries, the various sciences are studied in each year of the secondary school.

In the last year of compulsory science in the U.K. (grade 9), all pupils are introduced to each of biology, physics, and chemistry. These three subjects can be taken as separate, combined, or integrated courses. Most students study biology, chemistry, and physics as separate subjects.

There is some content that is common to all three countries. For example: exploration and discovery in space; meteorology, ecology and conservation; personal health (dealing with drugs and alcohol abuse; and diet and disorder); molecular biology, mechanics, dynamics, electricity, electrodynamics and electromagnetism; atom structure and function; methods and processes of science; and practical application to society.

It appears that all the countries included in this study share the same opinions concerning the method of teaching. All of them stress the use of hands-on and manipulative materials and audio-visual aids in the teaching of science. They also recommend the use of lecture, discussion, demonstration, laboratory projects, and library work in science teaching. Other approaches to science instruction include textbooks, computers, and the use of community resources, such as nature centers, museums, and zoos.

The examination system is different in each country. American and British students, by and large, take examinations to get out of school, but as Fiske (1983) put it, "Japanese take them (examinations) to get in." Assessment for graduation in Japan and the U.K. is external and it takes place at the end of lower and upper secondary level, although in the U.K. 50% of the GCSE mark is generated by the teacher. In the U.S.A. examinations are mainly internal and teachers are likely to use teacher-made objectives (short answer) tests in their examinations. They also use homework assignments, laboratory exercises, or projects, in assessing the work of their science students.

The outcomes of the comparison of science education policies in the countries studied and described in this chapter will be used in Chapter 6 to compare with the Lebanese policies, which will be described in the next chapter.

Chapter 5 Science Curriculum Policy in Lebanon Proposed for General and Advanced Students in Science

This chapter presents an analysis of science curriculum policies in Lebanon and compares them with those of the developed countries selected for this study. This analysis will be undertaken in the same sequence as in Chapter 3. Some of the information in this chapter was obtained during a visit to the Faculty of Education at the Lebanese University in Beirut, CERD and University of Notre dame, Beirut by the researcher in August, 1994.

Published data dealing with Lebanon are about 20 years old, due to the war in Lebanon which lasted for 17 years (1975-1992). Education, during this period, was not the first priority in the country and research in the field has not taken a prime place. There is no evidence in the literature that any changes have taken place recently. According to a member of the CERD in Lebanon, the science curriculum in use in schools is still the one that was proposed in 1970 (M. Yagi, personal communication, August 4, 1994).

Structure of the Educational System

The educational system in Lebanon is highly centralized. Virtually every aspect of education is planned and administered by a central Ministry of Education. Education in Lebanon is not compulsory at any school level. The educational ladder is still essentially the same as it was under the French

Mandate (Bashour, 1979). Figure 4, Appendix E (p. 232) shows the structure of the educational system in Lebanon today.

Students in Lebanon start elementary school at age 6. Most schools have a Kindergarten which lasts between 1 and 2 years. Education at the elementary level is a five-year program and children complete the last year around the age of 11. Students start lower secondary school level at the age of 11 and they usually stay there until the age of 15. The duration of lower secondary school, known as complementary or intermediate level, is 4 years. Students who succeed in the last year of the lower secondary schools have two options. They may sit for an entrance examination to "École Normale" where they study 3 years and end up with certification to teach elementary school, or they may continue their upper secondary school education known as the "Baccalaureate" which lasts three years (age 16-18) (Awad, Khoury, Jamoul, & Kanbar, 1984). Table 18 page 131 shows the organization of the school system in Lebanon.

Students start the upper secondary level at the age of 15 and finish at the age of 18. In the Years I and II of the upper secondary level, known as the Baccalaureate I (Bacc I), students choose courses from each of three sections: Language and Literature; Social Sciences; and Scientific sections where the curricula are very structured. Baccalaureate II (Bacc II) or the last year of upper secondary level also includes three sections: Philosophy, Mathematics, and Experimental Sciences (Ministry of Education and Fine Arts, 1970).

Table 18

The Organization of the School System in Lebanon According to the Age of the Student

Grade	Age	Number of Years spent at each level
Kindergarten	4-5	2 years
Elementary	6-10	5 years
Lower secondary or intermediate	11-15	4 years
Upper secondary	16-18	3 years

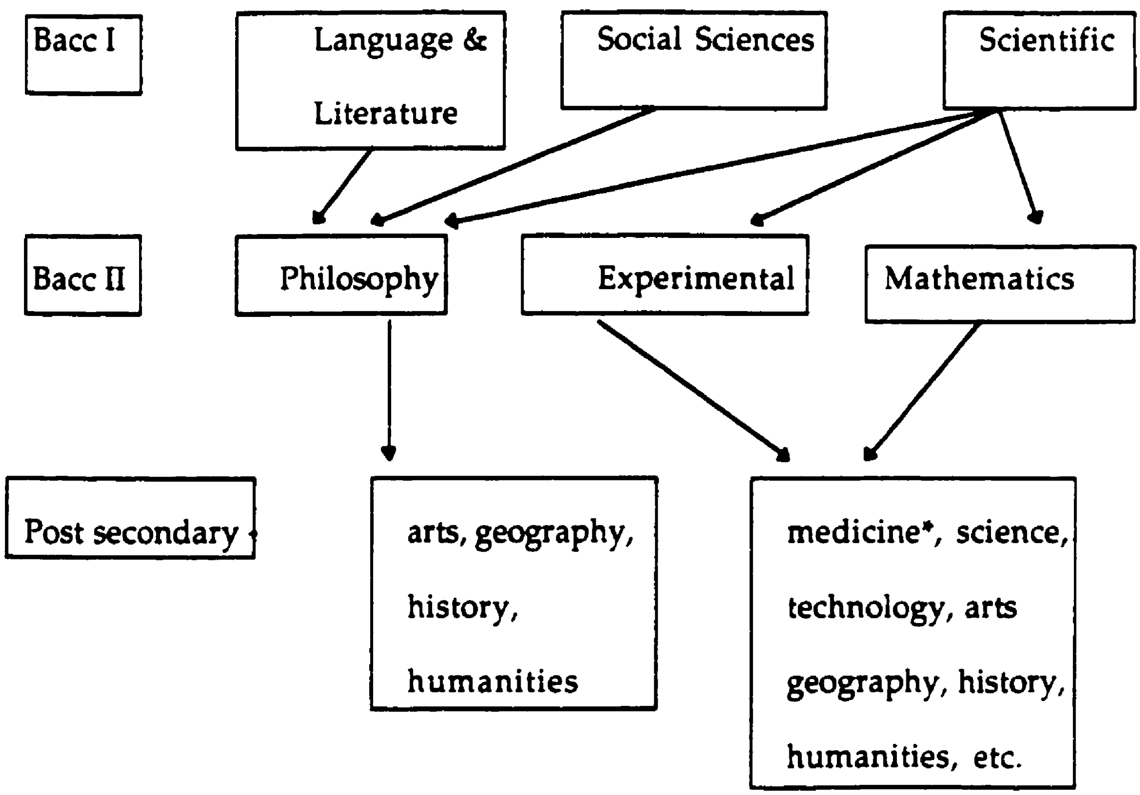
Note. From Almadrassat wa almoujtamak [School and society], by M. Awad, S. Khoury, M. Jamoul, and N. Y. Kanbar, (2nd ed.), 1984, Beirut, Lebanon: CERD; The official Lower Secondary School Programs of Instruction (p. Z17), by Ministry of National Education and Fine Arts, 1970, Beirut, Lebanon: Majalet Alsakafa.

Students graduating from Bacc I in both the Language and Literature and in the Social Sciences can only go to the Philosophy section in Bacc II, whereas students graduating from the Scientific section can choose any sections from the above three to continue with their education, so that these last 3 years of secondary education constitute the key for specialization at university level. A student who holds a Baccalaureate II diploma in the

Mathematics and Experimental Sciences can specialize in any areas of his/her choice, whereas the holder of Bacc II in the Philosophy section can only specialize in arts, geography, history and a few other non-scientific disciplines. Table 19 below shows the possible paths through the Baccalaureate levels.

Table 19

Possible Paths Through the Baccalaureate Levels



Note. Students with mathematics at Bacc II need one more course in biology if they wish to continue in medicine.

For the year 1992-1993 Table 20 below gives student enrollment in different types of schools (CERD, 1993). Statistical data on student enrollment have not been regularly published, so that this compilation provides the most recent picture of student enrollment in the three required sections of study.

Table 20

Student Enrollment in Different Types of School for the Year 1992-1993

Type of school	Level						
	Primary		Lower secondary		Upper secondary		Total
Public *(%)*	112 397	*(47)*	79 286	*(34)*	26 307	*(11)*	239 866
Private tuition *(%)*	146 691	*(39)*	106 200	*(28)*	39 168	*(10)*	380 202
Private free[a] *(%)*	87 675	*(25)*	-		-		87 675
Total *(%)*	346 763	*(49)*	185 486	*(26)*	65 475	*(9)*	707 743

Note. From Statistics for General Education: The School Year 1992-1993), by CERD, 1993, Beirut, Lebanon: Author.

[a] Free private schools or no tuition fees schools are those run by religious groups, where religion occupies a primary place of study in the school.

This table also shows the percentage of each age group attending school. According to El-Amine (1994) only 94% of children aged 5 - 9 years attend schools. The absence of legislation on compulsory schooling for children results in the postponed enrollment of some children in rural areas.

In Lebanon, the length of the school year is approximately 200 days divided into 2-3 terms. In the government guidelines there is no regulation on the time for school openings. It is only mentioned that school be opened from the end of September for school registration to the end of the following June. However students usually start school before October 10th and continue no later than June 20th. The date for opening and closing public schools is decided every year by the Ministry of Education. In the private school sector opening and closing days are left to the school administration and in most cases these schools open a few days after the public schools. The 200 days of each school year include registration times and other activities. The actual number of days of school instruction is around 160 days (Ministry of National Education and Fine Arts, 1970; M. Yagi, personal communication, August 4 1994).

Students in Lebanon attend school 5 days per week. The average length of the school day is generally 6 class periods and each period lasts about 55 minutes. The length of a period has been subject to change during the war. This was due to the fact that many schools were destroyed and some of them were used by refugees for accommodation. Also the migration of many families to secure areas obliged some schools to adopt 2 shifts per day to accommodate all the students. As a consequence, some schools reduced the length of a period from 55 to 50 minutes and sometimes to 45 minutes in order to allow for a second shift (Kraidy, 1983).

The length of the school day and the number of teaching days has an implication for the amount of curriculum that can be covered. This will be addressed in the recommendation, for change.

Classification of Aims and Objectives

The aims and objectives of science education in Lebanon as stated in the government guidelines for both secondary levels were analyzed and classified according to the categories of aims and objectives generated in this study and described previously. An examination of the list of aims and objectives shows that:

1. The aims and objectives are listed for the science syllabuses at each school level, and also for each individual science subject at the lower secondary level.

2. Many of the stated aims and objectives are repeated more than once in the same government document with some difference in the wording.

3. Some of the stated aims were confused, unclear, and subject to different interpretations. Therefore, it was sometimes impossible to classify some of them. An example is the following objective: "To make the child able to get by himself the knowledge of an adult which conforms to his intellectual maturity during all the stages of his development" (Ministry of National Education and Fine Arts, n.d, p. 273). This objective was taken to mean "to make the child an autonomous learner, appropriate to his maturity

level" and was classified as an affective objective although it would be difficult for a science teacher to decipher.

4. Lebanese science curriculum emphasizes science as an academic subject. At the lower secondary school level, the curriculum provides a list of science topics with a statement regarding the use of science process skills. At the upper secondary level, the curriculum provides a list of science topics with no mention of science process skills. According to a study carried out by Aboujaoude et al (1995) on students and teachers' definitions and perceptions of the purpose and usage of science, it appears that Lebanese middle school students and their teachers have a restricted view of science. Most of them defined science as an academic subject and perceived its purpose as to achieve high grades in science that prepare them to attain high status science-related professional careers. Students and teachers also perceived themselves and others using science in school-related setting and activities. The outcomes of this study show that students and teachers' perceptions of science reflect what the official Lebanese curriculum intends to do and to achieve.

Objectives in each domain are summarized in Table 21, page 137.

Table 21

Classification and Percentage of the Aims and Objectives of the Science Curriculum in Lebanon in Each Category and Domain

Domains	Objectives	Number	%
Cognitive	Science Content	3	18
	Breadth and Balance	1	6
	Intellectual Process	4	24
Total		8	48
Affective	Nature of Science	7	41
	Application to Science	1	6
Total		8	47
Psychomotor	Manipulative Skills	1	6
Total		1	6
Total		17	101

The results of the analysis presented in Table 21 show the following:

Aims and objectives in the cognitive domain are the most common in the Lebanese curriculum guidelines (48%). The aims and objectives in the affective domain are almost as evident where they form 47% of the total aims and objectives. In the psychomotor domain, aims and objectives are the least prevalent, comprising only 6% of the total.

Thus the Lebanese curriculum emphasizes the cognitive and affective domains, almost to the exclusion of the psychomotor domain.

The Pattern of Science Curriculum

Time allotted to the study of science

Science is studied in each grade at each school level. At the lower secondary level, science is compulsory for all students and optional science courses do not exist. Science is taught for three periods per week in grade 6, 7 and 8, and five periods in grade nine. Physical science is taught in grade 6, followed by natural science (biology) in grade 7, an earth science (geology) course in grade 8, and life science and nature of matter in grade 9 (Ministry of National Education and Fine Arts, 1970; 1971). Table 22, page 139 shows the distribution of the lower secondary school programs at each grade level.

Table 22.

Lower Secondary School Program, Hours per Week

School Subjects	Grades 6-8	Grade 9
Arabic Language	7	6
Fine Arts	1	1
Foreign language	7	6
Geography and history	3	3
Mathematics	5	5
Pedagogy or Civic Education	1	1
Physical Education	2	2
Religious Education	1	1
Science	3	5
Total	30	30

Note. From Tahdeed manahej al-taaleem fi almarhalat almoutawasita [The official Lower Secondary School Programs of Instruction] (p. Z38), by Ministry of National Education and Fine Arts, 1970, Beirut, Lebanon: Majalet Alsakafa.

At the upper secondary level, science is also a compulsory school subject for all students in the Social Sciences section (for general students), whereas it is not required in the Language and Literature section (general students who wish to specialize only in old languages). In the Social Sciences section, courses in chemistry and physics are offered at the Bacc I level (first two years) followed by physics and biology for the Philosophy (general student). The time allotted to science at each level of the upper secondary level varies from one year to another. It goes from 3-4 periods per week at Bacc I level to 7 periods per week at Bacc II level. Table 23, page 141 shows the time allotted for science courses for the general student.

Students in their final year of upper secondary level in the Language and Literature section are required to devote as much as 23.33% of their time to the study of science and yet they are not eligible to pursue any career in scientific areas. Tables 24, 25 and 26 pages 142, 143, and 144 show the general pattern of the secondary school program and the percentage of the time devoted to science subjects for the general students in the school curricula. This puts into question the purpose and content of the science curriculum for language and literature students.

Table 23

Approximate Time Allotment for Science Courses in Periods/ Week; and per Annum at Each Year of Each School Level for the General Student

Section	Lower secondary				Upper secondary		
					Bacc I		Bacc II
					Social Science		Philosophy
Year	1	2	3	4	1	2	3
No: of periods per week	3	3	3	4	4	3	7

Total of periods per week for both the lower and upper secondary levels	28
Total of hours per week for both the lower and upper secondary levels	23.3
Total of periods per school year for both the lower and upper secondary levels	896
Total of hours per school year for both the lower and upper secondary levels	746.7

Table 24

Upper Secondary School Program Planned for the General Student (1st, 2nd), School Hours/Week

Section	Language & Literature		Social Science	
	Year			
Subject Matter	1st	2nd	1st	2nd
Arabic language and Literature	7	7	7	7
Foreign Language and Literature	7	7	7	7
Old Language	4	5	0	0
History	2	2	2	2
Geography	2	2	2	2
Mathematics	3	3	3	3
Physics	0	0	2	2
Chemistry	0	0	2	2
Translation	2	1	1	2
Religious Studies and/or Pedagogy[a]	1	1	2	2
Physical Education and Fine Arts	3	3	3	3
Total Hours/Week	31	31	31	31

Note. From Tahdeed manahej al-taaleem fi almarhalat almoutawasita [The official Lower Secondary School Programs of Instruction] (p. D), by Ministry of National Education and Fine Arts, 1970, Beirut, Lebanon: Majalet Alsakafa; Bouniet alnizam altarbaoui phi Loubnan: Dirasa naiouiah [The Educational System in Lebanon] (p. 160-161) by M. Bashour, 1979, Beirut, Lebanon: CERD.

[a] Subject similar to civics and social sciences.

Table 25

Upper Secondary School Program Planned for the General Student (3rd Year), Hours/Week as of 1968.

Section	Philosophy[a]
Subject Matter	**3rd Year**
Pedagogy	1
History of Arabic Philosophy	6
General Philosophy	11
Physics	3
Biology	4
History	2
Geography	2
Physical Education and Fine Arts	1
Total Hours/Week	30

Note. From Tahdeed manahej al-taaleem fi almarhalat almoutawasita [The official Lower Secondary School Programs of Instruction] (p. D), by Ministry of National Education and Fine Arts, 1970, Beirut, Lebanon: Majalet Alsakafa; Bouniet alnizam altarbaoui phi Loubnan: Dirasa naiouiah [The Educational System in Lebanon] (p. 160-161) by M. Bashour, 1979, Beirut, Lebanon: CERD.

[a] Students who succeed in Baccalaureate I in the Social Sciences and Language and Literature sections can only go to Philosophy section for Baccalaureate II.

Table 26

Percentage and Time Allotment /Week of Science Teaching in the Upper Secondary School in Lebanon for the General Student

Year	Section					
	Language and Literature		Social Sciences		Philosophy	
	Total	%	Total	%	Total	%
Year 1	0	0	4	13		
Year II	0	0	3	10		
Year III	0	0	0	0	7	23

From tables 23, 24, and 25, pages 141, 142, and 143, it appears that in Lebanon at the upper secondary level, science is compulsory for all students with at least 10% of the timetable devoted to this subject.

<u>Science courses offered</u>

At the lower and upper secondary levels, there are no optional courses. However, optional sections exist, in which the program of study is structured in a way to prepare the student for specialization in science or art subjects. This is a reflection of the French curriculum and its impact on Lebanese education. Each year of the lower secondary level, the students are offered a new subject, for example: physical science at grade 6 followed by biology (known as natural science) at grade 7, earth science (Man and his environment) at grade 8, and finally at grade 9, two courses in life science and the nature of matter are offered.

At the upper secondary level, in the first two years, courses in chemistry and physics are offered for the general student in the Social Sciences sections. Physics, in addition to a biology course continue, to be offered in the third year for student in the Philosophy section.

Content and structure of science courses offered at the secondary level

Ministry of Educational Guidelines in Lebanon define the content of the science courses at each school level. The following describes briefly the content of science courses at the lower and upper secondary level. The science content at these level will be presented in detail in Appendix F (p. 233-242).

The content of science courses at the lower secondary level is as follows:

Table 27

The Content of Science at the Lower Secondary Level in Lebanon

Grade	Science subjects	Content
1		
	Physical science	heat and energy; water and its solution science and scientists; force and machines aspects of light, and sound; magnetism and electricity
2	natural science	diversity among animals; diversity among plants
3	man and his environment	physical environment; living environment
4	life science	cells as the basic structure of living things; how our bodies work; bacteria and health genetic continuity
4	nature of matter	kinetic molecular theory; nature of matter; structure of matter; carbon compounds

The content of science subjects at the upper secondary level in Lebanon is the following:

Table 28

The Content of Science at the Upper Secondary Level in Lebanon

Program Science Subjects	Content
Social Science	
physics (year 1)	mechanics; hydrostatics; heat
physics (year 2)	optics; magnetism; electricity; magnetic effects; electric energy; chemical effects
chemistry (year 1)	elements, molecules, atoms and compounds chemical bonding; changes of matter; symbols, formulae and equations
chemistry (year 2)	ions, acids, bases and salts; oxidation, reduction; chlorine, sulfur and related acids; sodium, calcium and related hydroxides; aluminum and iron
Philosophy	
physics (year 3)	dynamics; vibratory origin of sound; reflection of waves; interference of light; electromagnetic induction; alternating currents; transportation of electrical energy; electric emission (radiation) energy
biology (year 3)	cells and tissues; general organization of living organisms; animal biology (zoology); plant biology; general biology

Science Requirement for Graduation (Grade 10-12)

During the first four years of secondary school education, all subjects, including the sciences, are compulsory. However, in the senior years, optional sections with different requirements in science are offered. The minimum requirement in science is two chemistry, three physics and one biology course. These are offered in the Social Sciences (Bacc I) and the Philosophy (Bacc II) sections

Science Subjects and Content for Advanced Students in Science

At the upper secondary level, two or more science courses are offered for advanced students in science each year. Courses in chemistry and physics are offered at both year of the Bacc I level (year 1 and 2) in the Scientific section. In the last year of upper secondary level (Bacc II), courses in chemistry and physics for the Mathematics and Experimental Sciences sections and one course in biology for the Experimental Sciences section are offered.

The time allotted to science subjects at the upper secondary level for advanced students in science varies from a minimum of 7 periods per week at Bacc I level to 10 periods per week at Bacc II level. Table 29 page 149 shows the time allotted to the study of science by advanced students.

Table 29

Time Allotted to Science Subjects at Year I and II of the Upper Secondary School Level for Advanced Students in Periods/Week and Percentage of Total Time

Section	Mathematics						Experimental Sciences	
	Year							
Subject Matter	1st		2nd		3rd		3rd	
Chemistry #of periods (%)	3	(9.7)	3	(9.7)	4	(13.3)	4	(13.3)
Physics #of periods (%)	4	(12.9)	4	(12.9)	6	(20)	6	(20)
Biology #of periods (%)							5	(16.7)
Total #of periods (%)	7	(22.6)	7	(22.6)	10	(33.33)	15	(50)

Science courses offered for advanced students in science have certain similarities in content with those offered for general students for the same year and at the same level. For example in the first year of upper secondary level the content of physics course is the same for both general and advanced students, although the content of the chemistry course is different at this level.

In the Scientific section topics are more diverse and presented in a way that demand the learning of detailed content than in those of the Social Science section. In the second year, the main topics in physics and chemistry are studied in both Social Science and Scientific sections but with more variation and complexity in the Scientific section. In the third year of the upper secondary school level the content of physics and chemistry courses is the same for the Mathematics and Experimental Sciences sections. However it is considerably different from the physics course offered for the Philosophy section. Table 30, page 151 presents the content of science subjects for advanced students in science. Appendix G (p. 243-262) will present the content in detail.

In summary, a great variety of science courses is offered for advanced students in science. Despite the fact that the science courses planned for advanced students in science have content similar to those offered for general students, advanced students study science in greater depth, with more diversity and complexity of content. The content of science courses planned for both general and advanced student is presented in a traditional manner in the form of a collection of science topics that are old and irrelevant to the students' needs and interest. This content will be compared with the other three countries later in this chapter.

Table 30

Science Content for Advanced Students in Science

Program Science Subjects	Content
Scientific	
physics (year 1)	(see Table 28)
physics (year 2)	(see Table 28 with more emphasis on: optics, electricity, magnetism, magnetic effects, and electromagnetism); caloric and chemical effects ; electric energy, and it measurement
chemistry (year 1)	(see Table 28) with the addition of: atomic and ionic radii; coordinate bonds; matter and energy; calculation of composition by mass and volume; heavy water; carbon family
chemistry (year 2)	(see Table 28) with the addition of properties of solutions; theory of ionization; halogens; sulfur and nitrogen family; copper
Mathematics/Experimental Science	
physics (year 3)	dynamics, heat, optics and electricity
chemistry (year 3)	physical chemistry; organic chemistry
Experimental Science	
biology (year 3)	(see Table 28) with the addition of: endocrine glands, digestion and the sense organs; mineral and organic nutrition of plants; primary and secondary structure of different organs; theory of chromosomes; pollination and fruit formation; structure and germination of the seed

Teaching Strategies

The official instructional guide for programs of science at the four years of lower secondary school level stresses the importance of practical work in science teaching. In this context, teaching strategies are expected to be flexible so that students are given ample time for experimental work and activities. This would allow students to develop their manipulative skills and intellectual talents (Zogheib & Habib, 1983).

It is further suggested that instruction of science at the secondary level be diverse and characterized by approaches and procedures that balance concrete and abstract, observation and reasoning, deduction and induction and between various forms of memory. These approaches to teaching science content are considered beneficial in terms of increased motivation, student encouragement and promoting paired and group activities. As a result, students participate as much as possible in their own academic development. They can acquire a taste for social efficacy at the same time as they get a feeling for personal improvement (Ministry of National Education and Fine Arts, n.d).

Although the instructional guide stresses the importance of practical work in science teaching it is for the teacher to decide what teaching method will be suitable (Ministry of National Education and Fine Arts, n.d). It has been the researcher's observation that teachers do not have the background and are not prepared to do it. Furthermore the use of library facilities and the use of free reading in science research projects are not among the suggested teaching strategies. This may be due to the facts that the majority of schools lack libraries and that students are not prepared to do outside reading and personal work.

A closer examination of the instructional guide shows that the problems and processes of science are not stressed and the suggested practical activities are not challenging or provocative. Moreover these instructional guides tell students everything they are supposed to know leaving hardly anything new for them to find out. In light of what is known about how students construct their own knowledge and all the important contributions that science education can make, such as the development of scientific attitudes, interest, appreciation and practical skills, it is unfortunate that these contributions are not present in the teaching and learning situations stated in the instructional guide (Bashour, 1979).

It is probable that the apparent lack of intellectual stimulation in the instructional guide has led to teaching methods which are more traditionally oriented. As the study by Badro et al (1980) indicates, the methods most frequently used in Lebanon are teacher lectures and explanation, teacher-led discussions and, to a much lesser extent, teacher demonstrations with equipment. These methods of teaching are probably still in use in the postwar period (M. Yagi, personal communication, August 4, 1994). There have not been enough changes in teacher education to have any large effect on methodology.

There seems to be a contradiction between suggested teaching methods and the practical work prescribed in the Ministry of Education's official instructional guides accompanying the science programs. For instance, the prescribed practical work recommends that experiments be conducted by teachers. It also goes on to say that a "good experiment" is the one that is convincing, hence well-chosen, and that the experiment should work because failure is "awful" (Ministry of National Education and Fine Arts, n.d, p. 277). This apparent contradiction between prescribed practical work and suggested teaching methods prevents teachers from exposing students to the scientific method.

In summary, teaching methods at all levels of secondary education vary with the school and the teacher, ranging from traditional in most schools, to the most modern of methods in very few exceptional in spite of the fact that the official guide is very prescriptive (Kraidy, 1983).

Examinations

The promotion of a student to a higher grade is decided by the class teacher, except at the age of 15, and 18 where official national examinations are administered. At the age of 15, students may sit for the "Brevet d'Études Moyennes" diploma examination (also called Lower Secondary School Certification or "Lebanese Brevet") which entitles its holder to enter technical schools or to continue their education in arts or in science (Kraidy, 1983; Boujaoude, et al, 1995). It is taken at the end of the fourth year of lower secondary school (grade 9). The national examinations are norm-referenced tests, rather than a measure of the achievement of each student (Obeid, 1983).

The Lower Secondary School Certification or "Lebanese Brevet" is divided into 2 sections: Scientific and Literature. Students in both sections study the same curriculum in the same class and sit for the same exam; however, they are credited differently. The exam covers the final four years except for science, history, geography and civic education where the exam only covers the last year (Grade 9).

The passing of the Baccalaureate Diploma Examination (age 18) is required for university entrance. The Lebanese Baccalaureate is a national examination, administered by the Ministry of Education and is the only high school certificate recognized in the country. It is the "Ticket" for university entrance (Kraidy & Fares 1984) and civil service jobs. It also enables students to be admitted to European universities, especially those in France. It was instituted during the French Mandate on the model of the French Baccalaureate. It is administered at the end of the third year (Lebanese Baccalaureate Part II) (grade 12) of upper secondary school. The study program of the Lebanese Baccalaureate also follows closely its French equivalent (Kraidy & Fares, 1984).

Written examinations in physics and chemistry are compulsory in the Scientific and Social Sciences sections of the Lebanese Baccalaureate (part I) and in the Mathematics and Experimental Sciences sections of the Lebanese Baccalaureate (part II). Only the physics examination is compulsory in the

Philosophy section of the Lebanese Baccalaureate. In addition, there are no oral or laboratory examinations. Each of these examinations comprises two parts: the first is a set of theory questions of which the student has to answer a given number, the second is a compulsory problem with several questions which usually have to be solved in a given sequence. These two parts are given equal weighting.

The style of the national examination has had a strong influence on the orientation of students' work and on the school examination process in the whole country. The Lebanese Baccalaureate is generally regarded as a useful means of assessing students' achievements in the heterogeneous school system in Lebanon (Aboujaoude, et al, 1995; Kraidy & Fares, 1984). The Baccalaureate examinations have been under criticism in that they have not evolved significantly since they were established in the 1930s. The test instruments in science emphasize knowledge level objectives and encourage students to memorize facts. The evaluation procedures are highly selective with a rate of failure varying between 40% and 90%. Finally, while they are given exaggerated importance, the validity and reliability of these evaluation procedures are debatable (Kraidy, 1983; Kraidy & Fares, 1984).

Success and achievement in science in official examinations are the priority of Lebanese parents since success is considered to be important for obtaining a professional science-related degree that leads to high status careers and high income. While there are no official examinations at grade 7, 8, 9 and 11, school administrators and teachers struggle to complete the requirements of the science curriculum and try to provide students at these levels with the knowledge and skills that help them to pass the official examination and achieve high grades later on.

Summary of Government Policies in Science Education in Lebanon compared with those in the U.S.A., U.K., and Japan

This chapter has described government policies dealing with the school science curriculum in Lebanon. The description dealt with the following: the system structure and organization; the aims and objectives of the curriculum; the science instructional guidelines; the science content; teaching methods and approaches; and finally the system of examinations. These policies will now be summarized and compared with those in the other three countries.

System structure and organization

In Lebanon, education is not compulsory at any school level, in contrast to the U.S.A., U.K., and Japan where the minimum requirement for student attendance in school is at least up to the age of 15. Also, the time spent in school for teaching is around 160 days, whereas, in the countries studied student attendance varies between 180 and 245 days.

Aims and objectives

A comparison of the official statements of aims and objectives as stated in the official syllabus of the selected developed countries and Lebanon, has shown the following:

1. In Lebanon, a majority of the aims and objectives of the secondary school science as stated in Lebanese instructional guidelines are vague, carelessly stated in very general terms, and open to broad interpretation. This is in contrast with the other countries where objectives and aims are simply stated and clearly specified. It is difficult to see how science teacher in Lebanon can achieve the required emphasis without guiding principles. This lack of guiding principles could be due to the fact that Lebanese education since the colonial period has been influenced by the French system. The science curriculum in use in schools today is still the one developed in 1968 (for upper secondary level) and 1970 (for lower secondary level), which explains the continuing influence of the French system in Lebanese education. As a result of this influence, and the intervention of the war, Lebanese authorities have not yet formulated an explicit statement of a science education policy which would clarify the role, significance and contributions of science education at each school level. Further, there is no serious consideration of science in the school curriculum. For example, there is no indication of content that should be stressed in science teaching.

2. Certain aims and objectives considered important in policy for the teaching of science in other countries are not emphasized in the Lebanese policies for science education. These aims are:

- To stress the use of process skills and the scientific method through the development of inquiry into common things and experiences;
- To develop a positive attitude toward nature and scientific discovery;
- To understand the role and significance of science in modern society. This understanding is regarded as very important at the secondary level in the three countries studied. There appears to be an increasing awareness among science educators of the need to teach students about the relationship between science and society;
- To apply science/technology objectives. Examples are the practical applications of science (the products of engineering and technology) and the "process skills" used by engineers or technologists. These aims are strongly emphasized in all the State Education Department guidelines, but are nonexistent in the Lebanese guidelines. The lack of these aims in Lebanese curricula may be due to the fact that curriculum has not been revised since 1968, whereas in the selected countries, curriculum materials have been revised more recently.
- To help students at the upper secondary level to decide on a future career, and provide basic training and preparation for it. This objective involves the development of characteristics or qualities such as creativity and a

sense of responsibility and cooperation. In all the countries studied, official guidelines attach increasing importance to career education in order to increase young people's awareness of further education and career opportunities;

3. The instructional guidelines in Lebanon often appear in the form of a simple list of textbook chapters to be studied. There are no suggestions for the teachers as to the amount of time to be spent on each topics the depth of treatment, or the instructional materials to be used in the teaching of specific topics. The teacher is thus responsible for determining these components of the teaching process, which puts an extra load on the teacher.

Time Spent on Science

A large amount of time in the school timetable is devoted to the study of science in Lebanon. It varies from 10% of the total school time at the lower secondary level to 50% at the upper secondary level, depending on the level and the section chosen by the student. This would be laudable if the science content were worthy of so much time, but as this chapter has shown, the content is questionable. In all the four countries included in this study, the minimum amount of instructional time spent on each science subject or course is specified by the State Education Department. This time is approximately 400 to 500 hours at the secondary level in the three countries selected for comparison. In Lebanon it is a minimum of 750 hours at the same level. This shows that a big fraction of the school timetable in Lebanon is devoted to science subjects, although these subjects are a collection of topics of doubtful suitability. The 750 hours of science requirement at the secondary level also causes some imbalance among the other school subjects. As seen from the analysis, the selected developed countries have a more balanced school curriculum, with more appropriate topics in each science subject.

Science subject offerings

In Lebanon, science course selection is restricted to physics, chemistry and biology. A different science course is offered each year at the lower secondary level with the exception of grade 9, where two courses are offered. Courses in two or more of the above science disciplines are offered each year at the upper secondary level depending on the optional sections chosen by the student. No science courses are offered beyond those that are compulsory in each section. In the U.S.A., U.K. and Japan, a basic core of science is offered throughout the school years, beginning with an integrated science program in the early years of secondary education, continuing with a gradual move towards separate science courses during the middle years, and concluding with separate courses in physics, chemistry and biology in the senior years. In addition, each country offers a variety of alternative courses at the senior level, such as astronomy, botany, zoology, physiology, hygiene, ecology, environment, combined courses in two or more of the three main science subjects, and courses in interdisciplinary scientific areas.

Science subject content

In Lebanon the Ministry guidelines define the objectives and the content of the science courses in the most explicit way. In contrast to other countries studied, the content of science courses offered at the lower and upper secondary school levels in Lebanon is in the form of a collection of topics to be presented randomly by the teacher and studied by the student. Any logical sequence and continuity between a specific topic and the following topic is therefore absent. There seems to be no coordination among topics and no concern for whether students have the necessary background to understand the topic or the subject in question. The amount of information to be covered in each subject is enormous for the time allotted to it, consequently, there is no extra time for the teacher to add materials that are of interest to the students or to test teaching materials for feedback and revision.

In addition, there is a lack of topics dealing with the application of science and technology in society. A number of guidelines in the selected developed countries refer to the need to relate science to social studies. Science is integrated with other subjects such as environmental studies, technology, and sex education, hygiene, drugs, alcohol and tobacco, and their effect on the body, astronomy, science integrated technology (biotechnology, genetic engineering), and topics dealing with science invention, the methods and process of science are integrated. This integration is absent in the science curriculum in Lebanon.

Also, there is no relationship between school science content and students' everyday experiences outside school. The explanation for this as stated earlier in this chapter, is that the Lebanese secondary science curriculum is old, and when the curriculum was designed science education placed more emphasis on basic science courses than on the application of science. Science content should be revised frequently to meet the needs of both students and society, both of which are subject to change. The content of science courses in Lebanon is old, out of date, irrelevant to the needs and interest of students, and needs to be revised in order to follow new advances in science and science teaching.

Science requirement for graduation

At the beginning levels of secondary education science is mandatory for all countries in this study, including Lebanon. At the senior level, where greater course selection is permitted, science is a requirement at grade 10 in the U.S.A., U.K., and Japan. However, in Lebanon where the senior years are divided into three sections at least two science courses are required each year for students in all three sections. So while science requirement for high school graduation in the U.S.A., U.K., and Japan is three to four courses, in Lebanon the minimum science requirement for high school graduation is eleven courses. This emphasis on science makes the need for curriculum reform even more pressing.

Strategies for science teaching

To achieve a variety of educational aims, a corresponding variety of teaching strategies is required. This study examined curriculum guidelines that prescribed strategies for the achievement of stated aims. In general, guidelines provide few strategies for teachers. The methodology most frequently emphasized and used in Lebanon is lecture and explanation, and teacher-led discussion. The activities emphasized are mainly observation and demonstration with equipment. Several guidelines in the selected countries stress an "activity approach" based on constructivism in contrast to Lebanon where the problems and processes of science are not stressed. The development of skills in problem-solving, development of interests, appreciation and practical skills are not given any emphasis in curriculum guidelines in Lebanon, although they are in other countries. This has implications for the teaching strategies employed to deliver the curriculum

System of examinations

In-school evaluations in Lebanon involve examinations, course work, oral tests and written tests to assess aspects of scientific achievement. The official public examination for graduation is restricted to written testing. Even laboratory work is tested by paper and pencil tests in an examination room, not in the laboratory. Students are also required to answer questions based on practical work, but they are expected to provide answers based on memorization, not to do experiments during the examination. The theory questions of the examinations are usually concentrated on one area of the curriculum. Course work, oral tests and written tests, as well as public examinations are mainly concerned with evaluating the students' ability to repeat facts, not their ability to understand the underlying basic principles and to see significant relationships. Rarely is there concern with students' abilities to apply facts and principles to everyday situations as the case of the U.S.A., U.K., and Japan. In contrast with these countries, the school examination system in Lebanon focuses mainly on selecting students for further study, not on evaluating and testing students' learning and achievements while they are in school.

Curriculum guideline revision

In all the countries selected for this study, curriculum guides at all levels have been undergoing revision during the past few years. Rarely do ministry officials act alone in revising guideline documents. Usually an "ad hoc" committee involving university scientists, science education facilities and associations and organizations such as teachers', parents', the business community and other outside stakeholders, become directly involved in science curriculum policy deliberation. New revision in the countries studied is always subject to trial before implementation. In Lebanon, science curricula and programs in schools have not been subject to change since 1968 for the upper secondary schools and since 1970 for the lower secondary level. The members of the committee who are involved in the revision of science programs are usually chosen from the CERD staff and are mainly teachers, educators and administrators. No involvement from industry, business, parents and others is provided.

Problems and Needs

This analysis of both lower and upper secondary level and the comparison with countries that have exemplary science programs has identified major problems to be resolved in any serious effort to modernize school science in Lebanon. Also emerging from this analysis is the need to plan for science curriculum renewal in schools, and a series of measures to be taken. Following the pattern established earlier in the study, the problems will be summarized under the following categories: system structure; aims and objectives; pattern of the science curriculum; science requirements for graduation; teaching strategies; and student examination policy. This will lead to a series of recommendations which will be outlined in Chapter 6.

System structure and organization

Education in Lebanon is highly centralized with the Ministry of Education having total responsibility. Parents, students and community are not involved in making decisions about what should be learned and taught in schools, nor how it should be learned and taught. There is also no legislation on compulsory education as is the case in the other three studied countries.

Aims and objectives

Since aims and objectives are not clearly specified in the Lebanese guidelines, they are open to broad interpretation. The main focus of existing science curriculum in Lebanon is on academic preparation and what students need to know to become medical doctors and engineers to achieve higher social status. Aims and objectives that are considered important policy concerning the teaching of science in the other three countries studied are not stressed in Lebanese policies. For example, there is an absence of aims and objectives stressing the need to relate science to social studies; career education is not emphasized; there is a lack of aims that foster positive attitudes and develop skills for practical applications of science. The Lebanese objectives rarely incorporate students' everyday experience that can improve knowledge and skills and apply them to deal with everyday problems and issues as is the case in the three countries. Although the percentage of aims and objectives in Lebanon in each of the cognitive, affective and psycho-motor domains is similar to those in the studied countries, the content of each domain has different emphasis in the Lebanese curriculum.

Pattern of the science curriculum

Opportunities for providing adequate and balanced science courses at each school level and for each group of students are lacking. The ministry guidelines define the content of science courses in the most explicit way. In each science subject a collection of topics in that subject area presented without any logical sequence, defines the content. There are no optional science courses designed to meet the needs of general students, to stress the application of science to everyday experience, and to relate aspects of science and technology to societal issues.

Science requirement for graduation

Science content, although inadequate and unsuitable, is nevertheless compulsory for non-science students in Lebanon at all levels of secondary school, whereas in the three developed countries studied, science is not a compulsory subject after grade 9 or 10.

Teaching strategies

The centralized educational system also has an impact on teaching strategies. All aspects of teaching and learning are under the control of the Ministry of Education. The system does not leave any flexibility to the school or teacher in presenting the content. Course content has to be covered as a whole, since the students sit for the official examinations at the end of lower secondary school level, as well as Baccalaureates I and II. The amount of information to be covered in each subject is enormous for the allotted time. As a consequence, there is no extra time for additional materials of interest to the students and no opportunity for the teacher to test new or improved teaching materials for feedback and revision. Finally, not much emphasis is put on problem-solving approaches and use of scientific methods in teaching. Scientific concepts are not presented in an interesting manner.

Examination policy

The examination system is ineffective and highly selective, aimed at choosing the most able student, not at testing student learning and achievement. It emphasizes knowledge level objectives and encourages students to memorize facts. With such a system of examinations in place, opportunities to continue education are limited only to the most able student.

Summary

This chapter has identified problems with a number of aspects of the Lebanese science curriculum policy compared with policies in three developed countries. It has shown the need for reform in structure and organization of the system, aims and objectives, pattern of the science curriculum, science requirement for graduation, teaching strategies and examination policy.

There is a need to reformulate a new science education policy which would clarify the role, significance, and contributions of science education at each school level. This would necessitate some consideration of the place of science in the school curriculum, in order to indicate the stress to be put on various aims of science teaching. Finally there is a need to evaluate student learning appropriately.

In the next chapter recommendations based on the results of comparing science education policies in Lebanon with science education policies in the U.S.A., U.K., and Japan will be proposed for the solution of identified problems in Lebanon. These recommendations will be formulated to provide a strategy for curriculum development for general and advanced student in science at the secondary school level in Lebanon.

Chapter 6 Summary and Conclusions

The purpose of this study was to examine and analyze science curriculum policies in three selected developed countries (U.S.A., U.K., and Japan) in order to compare them with those of Lebanon, to draw recommendations to improve Lebanese science curriculum policies. The analysis was based on government documents, research and studies in the field, and UNESCO work. Curriculum policies, as published in the curriculum guideline or in the national curriculum in each of the selected developed countries, provided the data for the study. These data were categorized, analyzed and compared with similar data collected from Lebanon and problems with the Lebanese curriculum were identified. This chapter will propose recommendations for the solution of the identified problems by outlining basic strategies to develop a new science curriculum for general and advanced students in science at the secondary school level in Lebanon.

Recommendations toward a Strategy for Curriculum Development

There is a need to reform the science education policy in Lebanon. This could be accomplished if the Center for Educational Research and Development (CERD) and those responsible for education in Lebanon were to direct their attention to reformulate the goals and objectives of science teaching and learning. There is also a need to re-examine the time allotted to the science curriculum at various levels. The science subjects offered and the content of school science courses must be rationalized for students with different abilities, needs and interests. It would also be appropriate to re-examine the amount of detail that students are expected to retain, so that, content considered irrelevant to the needs of both general and advanced students in science would be removed from the curriculum. This section will outline the basic steps to be taken to develop a new curriculum for the lower and upper secondary school in Lebanon based on characteristic features in the three developed countries. There is a body of evidence that caution should be taken in transferring curriculum or materials from one culture to another, although it appears that the Japanese have made use of science materials produced in the U.S.A. and adapted them to their culture and their schools. This caution is proposed by Howson "During the 1960s project materials were translated and transferred between countries with insufficient thought given to the social, educational and cultural differences involved" (International Congress on Mathematical Education, 1977, p. 205). Thus, this chapter does not advocate the transfer of particular content from the science curricula of the three countries. Rather, it proposes the adoption of relevant features of the organization, structure and philosophy of the science curricula of these countries. Recommendations for curriculum development in Lebanon are presented in the same pattern used earlier in this study and address features considered to be important for reformed science curriculum policy in Lebanon

System structure and organization

From observations of educational systems in many countries, it should be recognized that education is a shared responsibility of government, schools, students and parents. All should be involved in the decision making. Support from business, community, social and other organizations is also needed in order to set up public school curricula for success by facilitating the transition between education and work. There should also be appropriate legislation to insure that a quality curricular frameworks exist. To accomplish this, representatives of government, educational policymakers, local school systems, public and private colleges and universities, parents, community-based organizations, local industries and businesses should all take part in the development of new curricula through participation, comments and suggestions. The CERD and those responsible for education should clearly identify the components to be addressed in science curriculum reform, set strategic plans with goals, objectives, activities, timelines, and responsibilities assigned, and provide technical assistance to help schools implement reform.

The ultimate goal for the new curriculum should be that all students have opportunities to learn and to improve their performance in science in all grades at the secondary school level. There should be a system in place to track program and student progress from 7th grade through 12th grade. The data gathered by this process should be used in comparative analyses to evaluate the progress and the efficiency of the new curriculum, rather than to evaluate student learning and achievement.

Compulsory education in Lebanon should also require minimum student attendance in school up to the age of 15, the current minimum requirement in all three studied countries. Finally, time spent in school should be increased from 160 days, a much shorter time than in the selected countries studied, where student attendance varies between 180 and 245 days.

In short, students, parents, teachers, employers, labor and community leaders should be involved in every aspect of the new curriculum. They should work together to develop a clear vision, and common goals for new directions in science education, and to promote action for curriculum improvement. This should be done with the goal of developing curriculum appropriate to the needs of all students.

Aims and objectives

The quality and relevance of schooling is critical to the future of the student and the society. There must therefore be balance in the goals of education. Preparing for the world of work, citizenship, personal development and preparing future scientists must all have their place in a revised curriculum.

Curriculum innovation in science should be conducted and made an on-going process. There is a need for clear well-stated educational goals and objectives to be achieved at each level of education, in each type of school.

These goals and objectives must be translated into a functional curriculum and plan of action for each level or type of school. The main aims of science teaching at the lower and upper secondary levels should be to prepare all students for future life.

Science curriculum in Lebanon should be designed not only to prepare medical doctors and engineers, but also scientifically literate individuals who can function in an increasingly technological society. In a society where students are confronted with environmental problems, the purpose of science education should not only focus on academic preparation for further careers in science and achieving higher social status, but should also put more emphasis on aims and objectives that help students in solving every day problems

Science curriculum in Lebanon needs to be more concerned with the development of practical skills, scientific attitudes, interests, and appreciation. There is the need to emphasize the understanding of scientific concepts and principles and their applications, and put less importance on the acquisition of detailed factual information. These skills will help students to apply their acquired knowledge in the world of work, to meet national priorities and needs, and to develop respect for and positive attitudes towards nature, skills and outcomes that are considered to be important by the three studied countries.

Pattern of the science curriculum

There is a need for a new science curriculum in Lebanon that would meet the needs of students in today's society, and still be appropriate for general students. Planning for science curriculum renewal at the lower and upper secondary levels should be directed to the needs of each of the following groups: a) those who will either leave school altogether after lower secondary level, or will go on to commercial, technical or other vocational training; (b) those who will proceed to upper secondary level to join the arts stream; and (c) those who will proceed to upper secondary level with intention of becoming science specialists. Two curricula should therefore be designed and developed. The first science curriculum should be planned to suit the students who either leave school at the end of secondary level and enter the workplace, or those who continue their further education in nonscience disciplines. The second curriculum should prepare those intending to be specialists for further study in science, as is the case for the upper secondary curriculum in the three studied countries. There is the need to provide a variety of optional science courses in the timetable to suit the needs for the general as well as the specialized students.

The three countries studied offer a basic core of science throughout the school years, beginning with an integrated science program in the early years of secondary education and continuing with a gradual move towards separate science courses during the middle years, and concluding with separate courses in physics, chemistry and biology in the senior years. This science curriculum pattern, if adopted in Lebanon, would introduce all students to the basic disciplines of science through integrated subjects. Then, students are prepared gradually to deepen their scientific knowledge in separate science courses. In addition, in the three studied countries, a variety of alternative courses at the senior level are offered and should be part of the curriculum in Lebanon. Astronomy, botany, zoology, physiology, hygiene, ecology, environment, combined courses in two or more of the three main science subjects, and courses in interdisciplinary scientific areas should be offered. Among the non-science majors at upper secondary level, many students take science without wishing to make a career of it. For these students, an integrated science course that combines all the science disciplines and shows a clear, relevant and balanced picture of technological and scientific enterprise would be most suitable. The time allotted to the study of compulsory science for the general student should not need to exceed 500 hours as is the case in the three developed countries. This would allow for a balance among all subjects, important in the education of generalists.

Care should be taken to avoid the presentation of any science syllabus as a list of individual topics or units of subject matter. Rather, it should comprise a listing of:

1. the tools of science that the student is expected to be able to use correctly and skillfully during the course;

2. the techniques of science that the student is expected to be able to understand and apply correctly;

3. the attitudes and problem-solving abilities that the science course should foster;

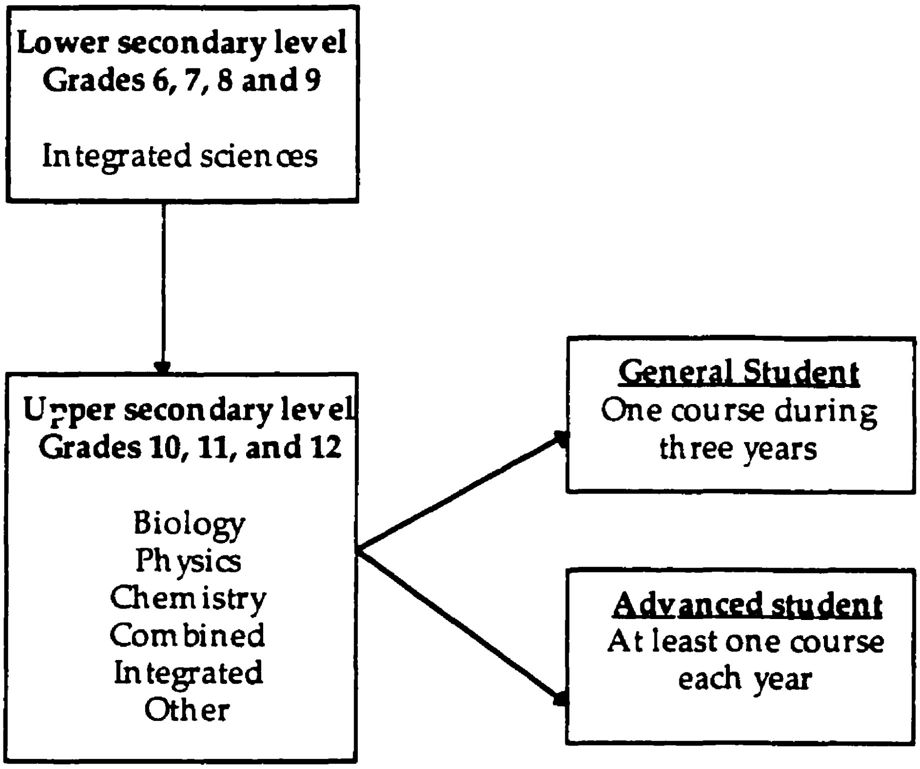
4. the facts, concepts and principles that the student is expected to understand, and whenever possible to apply or utilize in daily life;

5. the relevant information necessary to understand and appreciate science as a profession, and to acquaint students with some science-based careers, and aspects of the role of science in the economic, social and industrial development of Lebanon.

There should be regular revision and updating of the content of science. As mentioned earlier, in Chapters 2 and 4, the trend in science curriculum is toward the inclusion of areas that stress the application of science to everyday experience. As recommended by the International Program for Environmental Education (IPEE), attention should be paid to incorporating environmental topics into the science programs planned for general students at the secondary level. In addition, as in the three studied countries, effort should be made to integrate technological topics within science courses, and to link these topics to real life situations. This would have the effect of improving educational relevance to society, increasing productivity and ameliorating the quality of life, at a time when it is greatly needed.

<u>Science requirement for graduation</u>

Too much science is offered at the upper secondary level and required for graduation. Students in the non-science sections are required to study compulsory courses in physics, chemistry and biology with no options provided. Science curricula should be a planned to suit students of all abilities at all school levels. Therefore, compulsory science course offerings at the lower secondary levels need to be integrated. Students should be introduced to all science courses at the lower secondary level. Science could then be taught as separate disciplines in the upper secondary level with no more than one science course required for graduation as is the case in the three selected countries. The illustration on page 180 generalizes the suggested science courses that should be required for graduation for both the general and advanced student in science.



Teaching strategies.

There should be reform of the very highly centralized system for science curricula in Lebanon. Schools and teachers should have certain flexibility in teaching science subjects, choosing the materials, and the ability to revise their materials according to the needs and the interests of the students. Scientific concepts must be presented in an interesting manner with more emphasis on a problem-solving approach to teaching, on the scientific method and on the students' learning experiences. A program of research should be established to find new teaching techniques, inexpensive lab apparatus, and to develop teacher guides and programmed instruction.

Two approaches in teaching at the secondary school levels that are emphasized in recent research which have proved effective in teaching science are recommended for the new guidelines and curriculum reform. The first approach places emphasis on the constructivist approach to teaching and learning secondary school science. As mentioned in Chapter 2, in this model students construct their own knowledge, and control their own learning. This model helps the teacher to stimulate students' learning by involving them in decision making, so they can participate actively in all kind of learning situations, applying their developing knowledge and skills as well as sharing information and ideas.

The second approach is Cooperative learning which is defined as an instructional format in which students work together to achieve a particular goal or complete a task. As mentioned earlier in Chapter 2, cooperative learning enhances social skills among students; fosters learning, self-esteem, and positive attitudes toward school and classmates; and encourages development of higher-level intellectual skills. As stated by Johnson and Johnson (1996) cooperative learning has been found to be uniquely suited for science courses, and is a powerful tool to prepare students to live in an interdependent, diverse and rapidly changing world

If these two approaches to science teaching and learning in Lebanon are incorporated into science curriculum they will contribute to students' learning and achievement by making science classes more enjoyable and by fostering positive attitudes toward science. The implications for teacher preparation and training of such an advance, will be discussed briefly at the end of this chapter, although a detailed consideration of this topic is beyond the scope of the study.

A very important aspect of the process of learning that should be considered central in any approach to science teaching is practical science. It is valuable for both potential scientists and future non-scientists as it develops skills, coordination and reasoning. It also makes the study of science more interesting and more intelligible. The three studied countries emphasized practical work in their science programs. They believe that the best kind of learning is the one associated with practicing. Such practice takes place through students' investigations. It demands the active participation of students and with it they feel responsible for the outcomes of what they experience. This kind of learning increases the potential of student remembering, enables them to understand better the nature of scientific enterprise and helps them to develop problem-solving skills. Students in Lebanon should be actively involved in learning science. Practical science gives them the opportunity to think, formulate hypothesis, verify, share and discuss results, and apply what they learn to other situations outside the school. In other words, practical science is a simple and positive way to investigate scientific concepts in a lifelike manner. Teachers should assist students in planning and designing their practical activities in order to facilitate learning and achieve their instructional goals. In practical science, students should have many and varied opportunities for observing, note taking and sketching; collecting, sorting, recording data, and drawing graphs; dissecting, using hand lenses and microscopes, and exploring the chemical properties of common substances; cultivating plants, and observing behavior of humans and other animals. Students can use non-expensive materials to carry on their investigations and learn about science by working with real materials and phenomena and experiencing their biological and physical environment. Finally the use of well designed audio-visual materials in science teaching can make learning more appealing, interesting and relevant to students.

Students' examinations

The need for more and better techniques for assessing students' achievement in science is recommended. Practical assessment in science should be included in the final examination undertaken in school and then included in the final evaluation. Assessment items in the official examination should only test what the objective are designed to achieve, assessment items need to be more practical and understandable. Since classroom examination strategies should be consistent with instructional strategies and with objectives, the principle of curriculum alignment should be addressed by planners and teacher educators. It is important that curriculum and examinations in Lebanon should both serve the same purpose of improved student achievement. Therefore, official examinations should be changed to reflect the new curricular frameworks and standards.

In summary, science education in Lebanon should be compulsory and recognized as the responsibility of every (citizen) in the country. Government representatives, parents, teachers, and students should take a part in developing a new science curriculum appropriate to the needs of students (Macdonald, 1975). All students should be provided with an equal opportunity to learn and improve their scientific skills. Science curriculum at the lower and upper secondary levels should be designed to prepare both general and advanced students to become scientifically literate individuals and provide them with adequate and necessary skills that will help them to apply their scientific knowledge in the world of work in order to help them to solve everyday problems. This can be accomplished by providing a variety of science courses starting with integrated science courses in the early years of secondary education and continuing with a gradual movement toward separated science courses in the senior years. The content of the science courses should include areas that stress the application of science to everyday experience. The constructivist and cooperative learning approaches considered to be effective in science teaching should be emphasized and stressed in the new curriculum. Finally students' examinations should test what the objectives are designed to achieve.

Problems and Suggestions for Further Research

The analysis and comparison of science education policies in the selected developed countries with those in Lebanon has raised a number of further questions. During the course of analyzing and comparing the ministry policy documents in the selected developed countries with those in Lebanon, some recommendations for reform have been proposed, but a series of questions has emerged about other issues regarding the future direction of science education in Lebanon. Most of these questions cannot be answered definitively at this stage, but some suggestions for further research questions emerge from this study. Possible questions for further research are classified into four groups: orientation of science in schools, science teacher preparation, curriculum resources, and the financial situation.

Orientation of science in schools

How many different objectives can a science program be expected to reach? Some government documents from the countries studied specify as many as 10 different aims for a single science program. Guidelines at the middle and senior years often stipulate a broad range of aims. Should a program enable students to achieve many objectives or should a few be achieved thoroughly? No guideline document sets out aims in any order of priority. Can one assume therefore, that all of the stated aims are equally important? If not, what is the proper balance for the many varied aims?

These issues call for clearer definition than is provided in most ministry policies.

Science teachers

The question always facing us is what kinds of teachers do we need for Lebanon? Teachers need to be trained in new teaching approaches such as constructivism and cooperative learning. They need to be able to design laboratory activities, and Lebanon needs to establish a comparative position in terms of modern development in teacher education around the world. How to address to these questions depends to a large extent on political decisions, especially those related to education (Murr, 1983). Therefore further studies in teacher education are needed in Lebanon in order to establish priorities for teacher education programs.

Curriculum resources

Are teaching resources, particularly textbooks in Lebanon, adequate to allow desired objectives to be met? How can materials that contain useful resources, and other technological materials be made more accessible to the school, the teacher and the students? How can science activities outside school, which students find interesting, be related to science that they learn inside the school? Do science students need to develop all the skills of the experimental scientists as one of the objectives of science education? If so, laboratories and other physical facilities are required to achieve these objectives. But are "science and society" objectives best achieved through laboratory work? If not, what type of facilities are required to achieve these objectives?

Other curriculum resources such as computer technology, community resources, textbooks and audio-visual materials should be examined in order to improve the teaching strategies in Lebanon.

Financial situation

Even though major reform in science curriculum is timely and needed, is Lebanon able to support it financially? To what extent can the government spend on education at a time where the country is still recovering from the consequences of the war. We have to remember that all the efforts that are suggested and implemented will be for the benefit of the students who will be the generation leading the country into the future, which justifies the expenditure of money. Yet is there money available, no matter how justifiable the cause?

Summary

So, this study shows that schooling can no longer function in isolation from the realities of our living, and the process of learning must reflect the dynamic, open-ended and investigative dimensions of science. Science learning should be more than information absorption; students must be actively engaged in the process of learning so they can apply their observations, knowledge and interpretation of the world around them.

Students in Lebanon are lacking all the joy of learning science. Science subjects offered are old and far from modern realities. Science teaching presents science as a body of facts where students are not able to relate science to their everyday experience, rather than a learning experience in which students are confronted with real problems and are involved actively in finding solutions.

The present study has elaborated some recommendations to improve science teaching and learning in Lebanon. These recommendations are the outcomes of a comparison with three countries that are recognized as having strong history in science education, and a powerful influence on science teaching throughout the world. If Lebanon were to decide to implement curricular change in science, these countries present models that could guide the change process. In addition, the curriculum developers would need to become familiar with the definition of policy and the factors that influence the change process, both essential for real progress and both outside the scope of the study. From this perspective those responsible for education policy in Lebanon should set outlines to reform science education according to the needs of the student and the society; integrate the fundamental concepts of science into the curriculum; develop the skills that the student should acquire to facilitate their abilities to function in society; help the students to interpret their everyday science experiences; and to help the student to view the world scientifically and apply scientific methods and knowledge to solve everyday problems.

The fact that science courses are compulsory throughout high school is an indication that science is seen as very important, but no moves have been taken to address the importance in curriculum update and methodological advancement. Lebanon has the remains of a system that placed high value on science education. With the drain of wartime, revision and upgrading of curriculum has been set aside. It is now time to return to those educational goals. Fortunately there is research and practice available from the three studied countries to help Lebanon ease into the 21st century.

References

Aboumurad, M. (1985). Manehej altaleem alloubnanieh: 2 Alitar alssiassi alijtimai litataouriha phi ahed alistiklal. [Programs of teaching in Lebanon: 2. Its political and social evolution during independence]. Journal of Research Pedagogic, 13, (15), 31-71.

Abou Roujaily, K. (1985). Altaeleem alrasmi: Wakiouhou, aklafouhou wa aifaik tataourihi. [Public education: Reality, cost and its development]. Recherches Pedagogique, 12 (14), 7-35.

Aldridge, B. (1989, January-February). Essential changes in secondary science: Scope, Sequence, and Coordination, NSTA reports 1. NSTA.

Aikenhead, G. S. (1990). Assessment of student learning in the area of science-technology-society. In UNESCO, Innovations in science and technology education. vol. III. Layton, D (ed). (pp. 59-77). ([II] ED89.D.155-3/A). Paris: Author.

Aikenhead, G. S. (1991). Logical Reasoning in Science & Technology: (LORsT). Toronto: John Wiley of Canada.

Aikenhead, G. (1992, Winter). The integration of STS into science education. Theory into Practice, 31, (1), 27-35.

American Association for the Advancement of Science (AAAS). (1989a). Capabilities of the scientifically literate high school graduate. Unpublished paper.

AAAS. (1989b). Project 2061. Science for all Americans. Washington, DC: The American Association for the Advancement of Science, Inc.

AAAS. (1993). Benchmarks for science literacy: Project 2061. New York: Oxford University Press.

Anderson, C. (1987). The role of education in the academic disciplines in teacher preparation. Paper presented at the Rutgers Symposium on Education: The Graduate preparation of teachers. May 6-7).

Armstrong, R. J., Cornell, T.D., Kramer, R.E., & Roberson, E.W. (1970). The development and evaluation of behavioral objectives. Worthington, Ohio: Charles A. Jones Publishing Company.

The Association for Science Education (ASE). (1981). Education through science: Policy statement. Hatfield, U.K: Author.

Association for Supervision and Curriculum Development. (Summer, 1995). Reinventing science education: Reformers promote hands-on, inquiry-based learning. Willis, Scott. (ed). Curriculum Update, 1-8, (No 1-95186). Alexandria, VA.

Awad, M; Khoury, S; Jamoul, M, & Kanbar, N. Y. (1984). Almadrassat wa almoujtamak [School and society] (2nd ed.). Beirut, Lebanon: CERD.

Badro, R.G., & Kraidy, M.A. (1980). Development of a new physics curriculum for Lebanon. In Charles P. McFadden (Ed.), World trends in science education (pp. 143-149). Halifax, Canada: Atlantic Institute of Education.

Bashour, M. (1979). Bouniet alnizam altarbaoui phi Loubnan: Dirasa naiouiah. [The educational System in Lebanon: An empirical study]. Beirut, Lebanon: CERD.

BBC Radio for Schools and Colleges. (1984, December). An Education Now Broadsheet. Author.

Beauchamp, E. R. (1992). Japanese and U.S. education compared. Bloomington, IN: Phi Delta Kappa Educational Foundation.

Blank, R. K., & Espenshade, P. (1987, November). State education policies related to science and mathematics. Science and Mathematics Indicators Project. (ERIC Document Reproduction Service No. ED 288 724).

Bloom, B. S. (1956). Taxonomy of educational objectives: The classification of educational goals. Handbook 1: Cognitive domain. NY: David McKay Company, Inc.

Bloom, B. S., Hastings, J. T., & Madaus, G. F. (1971). Handbook on formative and summative evaluation on student learning. New York: McGraw-Hill.

Bloom, B. S., Krathwohl, D. R., & Masia, B. B. (1984). Taxonomy of educational objectives: The classification of educational goals. New York: Longman.

Boujaoude, S. (1996). Epistemology and sociology of science according to Lebanese educators and students. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, (St. Louis, MO, March 31-April 3, 1996). (ERIC Document Reproduction Service No. ED 394 848).

Boujaoude, S., & Khalid, F. A. (1995). Lebanese middle school students' definitions of science and perceptions of its purpose and usage. Paper presented at the Annual Meeting of the National Association for Research in Science teaching, (San Francisco, CA, April 22-25, 1995). (ERIC Document Reproduction Service No. ED 387 328).

Brinckerhoff, R. F., & Yager, R. E. (November, 1987). Science and technology education for tomorrow's world. A report of the Exeter II conference on secondary school science education. Exeter, NH: NSTA. (ERIC Document Reproduction Service No. ED 276 575).

Bybee, R. (1980). Science education policies for the 1980s and beyond. Northfield, Minnesota: Carleton College.

Bybee, R., & Landes, N. M. (1990). Science for life and living: An elementary school science program for Biological Sciences Curriculum Study. The American Biology Teacher, 52, 92-98.

California State Board of Education. (1985). Model curriculum standards: Grades nine through twelve: Science. Sacramento, CA: Author.

The Center for Vocational Education. (1977). Category C: Instructional Execution. Columbus, OH: The American Association for vocational instructional materials (AAVIM).

Central Office of Information. (1985). GCSE the new exam system at 16-plus (No. EDUCJ0021NJ). London: Author.

Central Office of Information. (1987). Education in Britain. (No. 15/87). London: Author.

Central Office of Information. (1988, January). Education reforms in Britain. [No 301/88 Classification 4(b)]. London: Author.

The Center for Educational Research and Development (CERD). (1974). Survey of opinion on the baccalaureate curriculum. Beirut, Lebanon: Author.

CERD. (1978, April). The Center for Educational Research and Development: Aims , organization and functions. Beirut, Lebanon: Author.

CERD. (1981). Tadreess Alouloum. [Science Teaching]. Tohmi, T (ed). Beirut: Author.

CERD. (1993). Alihsaat aloualiah liltaleem alam. Alam aldirassi 1992-1993. [Statistics for general education: The school year 1992-1993]. Beirut, Lebanon: Author.

CERD. (n.d). Aloussos alamat likat alasilat lilchahadat almoutawasitat. [General structures for the examination for lower secondary school certification]. (Report No 12). Beirut: Author.

Cheek, D. (1989). Thinking constructively about science, technology, and society education. Unpublished doctoral dissertation. Pennsylvania Estate University: University Park.

Chisman, D. G. (1990). What is integrated science teaching: Its beginnings and its place today. In UNESCO. (1990). New trends in integrated science teaching, volume VI (pp. 13-17). Paris, France: Author (ERIC Document Reproduction Service No. ED 347 054).

Cobb, P. (1994, October). An exchange: Constructivism in mathematics and science education. Educational Researcher, 23, (7), 4.

Connect. (1985, March). Tenth anniversary of the UNESCO-UNEP International Environmental Education Program, 1975-1985. UNESCO-UNEP Environmental Education Newsletter, 10, 1-8

Cooper, E. F. (1983, April). U.S. science and engineering education and manpower. Background, supply and demand; and comparison with Japan, the Soviet Union, and West Germany. Report prepared by the Congressional Research Service Library of Congress for the subcommittee on science, research and technology, transmitted to the committee on science and technology. U.S. house of representative, ninety-eight congress, first session. (ERIC Document Reproduction Service No. ED 235 996).

Corm, G. (1986). Geopolitique du conflit libanaise: Etude historique et sociologique [Geopolitics of the Conflict in Lebanon: Historical and sociological studies]. Paris: La decouverte.

Department of Education and Science. (1989). The curriculum from 5 to 16 (second ed). London: Her Majesty's Stationery Office.

Department of Education and Science Welsh Office (DESWO). (1984). Education in Britain. Britain: Central Office of Information.

DESWO. (1985, March). Science 5-16: A statement of policy. London: Her Majesty's Stationery Office.

DESWO. (1988, August). National curriculum. Science for ages 5 to 16. Proposals for the secretary of state for education and science and the secretary of state for Wales. London: Author.

Direction générale de l'information, Ministère des affaires étrangères, Japon. La Vie au Japon. (1979, April). L'enseignement au Japon. [Education In Japan]. Japan: Ministry of Foreign Affairs. Code No 05501.

Driver, R., Asoko, H., Leach, J., Mortimer,. & Scott, P. (1994). Constructing scientific knowledge in the classroom. Educational Researcher, 23, 5-11.

Dyasi, H. (1979). Future developments in integrated science education in relation to environmental education. In J Reay (ed), New trends in integrated science teaching: Vol. 5 (pp. 111-7). Paris: UNESCO. (The Teaching of Basic Sciences).

Ebenezer, J., & Zoller, U. (1993). Grade 10 students' perceptions of and attitudes toward science teaching and school science. Journal of Research in Science Teaching, 30, 175-186.

Education Information Section. (1995, July). School level Examinations (Information Group No 209 131). London: The British Council.

Edwards, P. (1987). Educational framework for school technology. In Riquarts, Kurt (Ed), Science and technology education and the quality of life: Volume 2: Technology Education: Science-Technology-Society. Proceedings of the 4th International IOSTE symposium on world trends in science and technology education. (pp 377-389). Kiel 4-12, August. Federal Republic of Germany: Institute of Science Education.

Eid, F. N., Kassab, E. E., Sarkis, M. K., & Zraibi, E. K. (1979). Analyse taxonomique des épreuves de physique et de chimie du baccalauréat libanais. Mémoire présenté en vue de l'obtension du CAPES en physique. Beirut: Université libanaise.

El-Amine, A. (1994). Altaileem phi Loubnan. Zayaîa wa machehed. [Teaching in Lebanon: Characteristics and observations]. Beirut, Lebanon: Dar Aljadid.

Encarta. (1997). Liban. Encyclopédie Microsoft (R) Encarta (R) 97. (c) 1993-1996 Microsoft Corporation. Tous droits réservés.

ERIC/SMEAC Science Education Digest. (1990). Current projects and activities in K-12 science education curriculum development. ERIC Clearing House for Science (Report No EDO-SE-90-27). Columbus, OH: Mathematics, and Environmental Education, 3 (ERIC Document Reproduction Service N0 ED 324 194).

The Exeter Conference on Secondary School Science Education. (1980). Report of the Exeter I conference, June 15-22, 1980. Exeter, NH: Phillips Exeter Academy.

Feature. (1988, August). Schools to become more accountable to pupils' parents. Nash, Ian (Ed). London: London press Service.

Fiske, E. B. (1983). Education in Japan: Lessons for America. New York Times 10, 11, 12, 13, July 1983.

Gadsden, T., Bectech, P., & Dawson, G. (1979). The design and content of integrated science courses. In, J Reay (ed), New trends in integrated science teaching: Vol. 5, (pp. 41-50). Paris: UNESCO. (The Teaching of Basic Sciences).

Gardner, M. (1991, March). Science education: A global perspective. The Science Teacher, 58, (3), 46-47.

Gergen, K. J. (1982). Toward a transformation in social knowledge. NY: Springe-Verlag.

German, G. H. (1996, June 1). Beyrouth aux 17 civilisations [Beirut with 17 civilizations]. L'Actualité, 56-64.

Gutesk, G. L. (1983). Education and Schooling in America. New Jersey: Prentice Hall, Inc.

Haggis, S, & Adey, P. (1979). A review of integrated science education worldwide. In: J Reay (ed), New trends in integrated science teaching: Vol. 5 (pp. 35-9). Paris: UNESCO. (The Teaching of Basic Sciences).

Harrow, A. (1972). A taxonomy of the psychomotor domain: A guide for developing behavioral objectives. NY: David McKay.

Hasegawa, I. (1993, July-August). Education japonaise [Japanese Education]. Etudes. (1-2), 37-44.

Hassard, J. (1990, March). Cooperative classroom. Science Scope, 36-39.

Hofwolt, C. A. (1986). Instructional strategies in the science classroom. In, D. Holdzkom & P. B. Lutz (eds), Research within reach: Science education (pp. 43-57). Columbus, OH: Ohio Department of Education.

Hurd, P. de H. (1984, July-September). Biology for life and living: Perspectives for the 1980s. Biology Education, 5-9

Hurd, P. de H. (1991a). Closing the educational gaps between science, technology, and society. Theory into Practice, 30, 251-259.

Hurd, P. de H. (1991b, October). Why we must transform science education. Educational Leadership, 49, 33-35

IAEP 88. (1989, January). A world of differences: An international assessment of mathematics and science. Lapointe, Archie,. E, Mead, Nancy. A, Phillips, Gary. W. (eds). Report No CAEP-o1. Princeton, N.J. Educational Testing Service.

IAEP. (1992, February). Learning science. Lapointe, Archie. E., Askew, Janice. M.,& Mead, Nancy, A (eds). Report No 22-CAEP-02. City Princeton, N.J: Education Testing Service.

International Association for the Evaluation of Educational Achievement (IEA). (1988). Science achievement in seventeen countries. A preliminary report. Oxford: Pergamon Press.

International Congress on Mathematical Education, 3rd, Karlsruhe, 1976. (1977). Proceedings of the Third International Congress on Mathematical Education. Karlsruhe: University of Karlsruhe

Intergovernmental Conference on Environmental Education: Tbilisi: (USSR): 1977. (1978). Final report. Paris: UNESCO. (UNESCO doc. ED/ MD/49).

Ito, N., Nakayama, H., Shibanuma, S., Beppu, A., Hayashi, D., & Oki, M. (1975). "Basic Science" in upper secondary school education in Japan I: The recent revision of the science curriculum for upper secondary schools and introduction of basic "Science" to the new "Science". Science Education, 59 (4), 475-480.

Jacobson, W. J. (1986, September). The United States science curriculum case study. Paper presented at the United-States-Japan Seminar on Science Education (Honolulu, HI. September 14-20, 1986). (ERIC Document Reproduction Service No ED 278 564).

Jacobson, W. J., Doran, Rodney. L., Humrich , E., Kojima, S., Miyake, M., & Takemura, S. (1986). Analyses and comparison of science curricula in Japan and the United States. (Report No. NIE-p-85-3062). New York: Second IEA Science Study. (ERIC Document Reproduction Service No. ED 271 395).

Johnson, D. W., & Johnson, R. T. (1984). Circles of learning cooperation in the classroom. Alexandria, Va.: Association for Supervision and Curriculum Development.

Johnson, D. W., & Johnson, R. T. (1989). Cooperation and competition: Theory and research. Edina, MN: Interaction Book Company.

Johnson, D. W., Johnson, R. T, & Holubec, E. J. (1996). Learning together in the classroom: Practical applications. In R. J. Stahl (Ed), Cooperative learning in science. A handbook for teachers (pp. 49-73). Menlo park, CA: Addison-Wesley Publishing Company.

Kazuo, I. (1990). The Japanese Educational System. In K. Michiko (Ed), Japan from a Japanese perspective. Tokyo: International Society for Educational Information, Inc. http://nserv.ei.nsc.co.jp/isei/index.html. accessed 96/09/25 via Netscape 2.0.

Keys, W. (1986, November). A comparison of A-level science students in schools, Sixth-Form Colleges and colleges of further education. Educational Research, 28, 190-201.

Keys, W. (1987). Aspects of science education in English schools. Washington, DC: National Foundation for Educational Research.

Klopfer, L. E. (1971). Evaluation of learning in science. In B. S. Bloom, J. T. Hastings, & G. F. Madaus (Eds), Handbook of formative and summative evaluation of student learning. (pp. 559-641). New York: McGraw-Hill Book Company.

Kraidy, M. (1983). Lebanon: System of education. Invited contribution to the International Encyclopedia of Education. Research and Studies. Oxford, England: Pergamon Press.

Kraidy, M, & Fares, J. (1984). Taxonomical analysis of the Lebanese baccalaureate physics and chemistry examinations. Science Education 6, 91-98.

Krathwohl, D. R., Bloom, B. S., & Masia, B. B. (1964). Taxonomy of educational objectives, handbook II: Affective domain. New York: David McKay Co.

Kyle, W. C. (1984). Curriculum Development Projects of the 1960s: What became of the curriculum development projects of the 1960s? What did we learn from them that will help teachers in today's classrooms? In D, Holdzkom & P, Lutz (Eds), Research within Reach: Science Education: A research-guided response to the concerns of educators, (pp. 3-24). Charleston, W.V.: Research and Development Interpretation Service, Appalachia Educational Laboratory, Inc.

Lauterbach, R., & Mehta, J. (1987). Group Report: Main working group: Science education. In Riquarts, Kurt (Ed), Science and technology education and the quality of life: Volume 3: Proceedings of the 4th International IOSTE symposium on world trends in science and technology education (pp. 179-192). Kiel 4-12, August. Federal Republic of Germany: Institute of Science Education (IPN).

Lawton, D., & Chitty, C. (1988). The National Curriculum. London: Institute of Education.

Layton, D. (1988). Innovations in Science and technology education. Vol. II. Paris: UNESCO.

Lebanese Ministry of Planning. (1972). Population active au Liban [Active population in Lebanon]. Beirut: Author.

Lee, W. O. (1991, February). The search for excellence and relevance in education: Lessons from Japan's fourth educational reform proposals. British Journal of Educational Studies, 39, (1), 17-32.

Lorber, M. A. (1996). Objectives, Methods, and evaluation for secondary teaching (4th ed). Boston, MA: Allyn & Bacon.

Maybury, R. (1975). Science education. Technical assistance and innovation. New York: John Willey and Sons.

McCall, R., & Wilcox, J. (1985). 15+ Science practical testing- -A vehicule for curriculum reform. Assessment of Performance Unit (APU) Newsletter, (7) 5-6.

Macdonald, J. B. (1975). Curriculum and human interest. in Wm Pinar (ed), Curriculum theorizing: The reconceptualists (pp. 283-294). Berkeley, California: McCutchan Publishing Corp.

McKnight, C., Crosswhite, F. J., Dossey, J. A., Kifer, E., Swafford, J. O., Travers, K. J., & Cooney, T. J. (1987). The underachieving curriculum. Champaign, IL: Stipes.

Miller, J. (1986). An analysis of science curricula in the United States. Second IEA Science Study (SISS), United States. (Report No SPA-8470382). New York: Second IEA Science Study. (ERIC Document Reproduction Service No. ED 275 534).

Ministère des affaires étrangère. (1983). Le Japon aujourd'hui. [Japan today]. Japan: Author.

Ministry of Education, Science and Culture (1982). Education in Japan: 1982: A graphic presentation. (Rev. ed.). Japan: Ministry of Education, Science and Culture, Government of Japan.

Ministry of Education, Science, and Culture. (1983a). Course of study for lower secondary schools in Japan. (No 156). Tokyo: Ministry of Finance.

Ministry of Education, Science, and Culture. (1983b). Course of study for upper secondary schools in Japan. (No 163). Tokyo: Ministry of Finance.

Ministry of Education, Science, and Culture. (1989a). Chugakko Gakushu Shidoyoryo. [The course of study for lower secondary schools]. Tokyo: Ministry of Finance.

Ministry of Education, Science, and Culture. (1989b). Gakushu Shidoyoryo. [The course of study for upper secondary schools]. Tokyo: Ministry of Finance.

Ministry of National Education and Fine Arts. (1968). Tahdeed manahej al-taaleem fi marhaletlt altaeleem alsanawi. [The official upper secondary school programs of instruction]. Beirut: Majalet Alsakafa.

Ministry of National Education and Fine Arts. (1970). Tahdeed manahej al-taaleem fi almarhalat almoutawasita. [The official lower secondary school programs of instruction]. Beirut: Majalet Alsakafa.

Ministry of National Education and Fine Arts. (1971). Tahdeed manahej al-taaleem fi almarhalat aloubtidaiat. [The official primary school programs of instruction]. Beirut: Author.

Ministry of National Education and Fine Arts. (n.d). Educational Instructions: For the use of the teachers of elementary and intermediate grades. Beirut: Author.

Molyneux, K. (1987, August). Games, simulations, and role-play as teaching strategies for STS: Science Technology, and Society. In Riquarts, Kurt (Ed), Science and technology education and the quality of life: Volume 2: Technology Education: Science-Technology-Society. Proceedings of the 4th International IOSTE symposium on world trends in science and technology education (pp. 752-756). Kiel 4-12, August. Federal Republic of Germany: Institute of Science Education (IPN).

Murr, G. (1983). The preparation of mathematics and science teachers for public schools. In Proceedings: Mathematics and science education in the elementary and intermediate cycles in Lebanon, (pp. 82-87). A conference sponsored by the Science and Mathematics Education and Extension Programs: November 18-19, 1983. Beirut, Lebanon: American University of Beirut.

National Academy of Sciences. (1990). Fulfilling the promise: Biology education in the nation's schools: Committee on High-School Biology Education: Board on Biology: Commission on Life Sciences: National Research Council. Washington, DC: National Academy Press. (ERIC Document Reproduction Service No. ED: 326 436).

National Center for Education Statistics. (1993). Schools and staffing in the United States: A statistical profile, 1990-91. Washington, DC: Government Printing Office. (Report No: NCES 93-146).

National Curriculum Council. (1989a). The National Curriculum: An introduction: The new terminology: Author.

National Curriculum Council. (1989b). Science: Secondary science: Author.

National Curriculum Council. (1989c). The National Curriculum: Planning the curriculum: Author

National Curriculum Council. (1989d). The National Curriculum: Record keeping and assessment. Author.

National Institute for Educational Research (NIER). (1986). A study of some critical aspects of secondary education in the countries of Asia and the Pacific: Research proposal: Report of a regional workshop. (Report No NIER-RW/86/7). Tokyo, Japan, June 17-July 10 1986, (ERIC Document Reproduction Service No 297 427).

NIER. (1987). Educational facilities in Japan. NIER occasional paper 01/87. Tokyo: Author. (ERIC Document Reproduction Service No 297 431).

National Research Council (NRC). (1996). National Science Education Standards. Washington, DC: National Academy Press.

National Science Board, Commission on Precollege Education in Mathematics, Science and Technology. (1982, October). Today's problems tomorrow's crises. A report of the National Science Board Commission on Precollege Education in Mathematics, Science, and Technology. Washington, DC: National Science Foundation.

National Science Board, Commission on Precollege Education in Mathematics, Science and Technology. (1983). Educating Americans for the 21st century: A report to the American people and the National Science Board. Washington, DC: Author.

National Science Board. (1993). Science and engineering Indicators. Washington, DC: National Science Foundation.

The National Science Teacher Association (NSTA). (1982, November). Science-Technology-Society: Science Education for the 1980s. Washington, DC: Author.

NSTA. (1987). Criteria for excellence. Washington, DC: Author.

NSTA. (1990). Scope sequence and coordination of secondary school science. Washington, DC: Author.

NSTA Task Force. (1990). NSTA Position Paper: Qualities of a scientifically and technologically literate person. Washington, DC.: Author.

NSTA. (1993). Scope sequence and coordination of secondary school science. Volume 1: The content core: A guide for curriculum designers. Washington, DC: Author.

NSTA. (1995). Scope sequence and coordination of National Science Education Content Standards: An addendum to the content core based on the 1994 draft National Science Education Standards. Arlington, VA: Author.

New York, State Education Department. (1984, November). New part 100 of the commissioner's regulations. NY: Author.

Nishikawa, J., & Kobayashi, M. (1986). Recent revision of the science curriculum for upper-secondary schools in Japan. Science Education, 70, (2), 123-128.

Nogami, T., & Jacobson, W. J. (1987, March 27). Science education in Japan: A comparison with the U.S. Paper presented at the meeting of the National Scien^e Teachers Association, 35th National Convention. Washington, DC.

Obid, M. A. (1983). Construction d'un test standarisé pour les sciences physiques au cycle moyen. [Constructing a standardized examination in physical science at the lower secondary level]. Unpublished master's thesis, Université libanaise, Beyrouth, Liban.

O'brien, T. (1993). Teaching fundamental aspects of science toys. School Science and Mathematics, 93, 203-207.

Pedagogica Europea. (1973). The Assessment of Students' course work in technological studies at the secondary school level, 7, 94-113.

Pring, R. (1989). The New Curriculum. London: Cassell Educational Limited.

Public Information, Bureau, Ministry of Foreign Affairs, Japan. Facts about Japan. (1976, May). Education in Japan. Japan: Ministry of Foreign Affairs. Code No 05 501.

Ramsey, J. 1993). Survey of perceived needs of Houston-area middle school science teachers concerning STS goals, curricula, inservice, and related content. School Science and Mathematics, 93 (2), 86-91.

Samdy, S. R. (1984). Opening Address: International Symposium on Students' Interest in Science Education. In Interest in science and technology education. Lehrke, M; Hoffmann, L; Gardner, P. L. (eds) (pp. 13). Kiel: Institute for Science Education.

School Curriculum and Assessment Authority (SCAA). (1995a). GCSE examination results. London: Author.

SCAA. (1995b). A & AS examination results. London: Author.

School Curriculum Development Committee: Information Centre. (n.d.). The educational system of England and Wales. London: Author.

Science Council of Canada (SCC). (1984, April). Background study 52: Science education in Canadian schools volume I: Introduction and curriculum analysis. Orpwood, Graham, & Souque, Jean-Pascal (Eds). Hull, Quebec: Ministry of Supply and Services.

Science Education Newsletter 1. (1981). Activities in Britain: 2. The school curriculum: Mathematics and science. The British Council.

Science Education Newsletter 56. (1984). Activities in Britain: 1. Secondary Science Curriculum Review: Aims and projected outcomes. The British Council.

Science Education Newsletter 61. (1985, May). Activities in Britain: 1. Department of Education and Science: Science 5-16- a statement of policy. The British Council.

Science Education Newsletter 61. (1985, May). Activities in Britain: 5. Technology in the Secondary Science Curriculum Review. The British Council.

Science Education Newsletter 66. (1986, March). Activities in Britain: (Modular Secondary Science Resources (MSSSR): ILEA. Manchester: The British Council.

Science Education Newsletter 78. (1988). Activities in Britain: Science Education in 1988: Some impressions from the annual meeting of the Association for Science Education (ASE) at the University of Nottingham, 2-5 January 1988. Manchester: The British Council.

Science Education Newsletter 134. (1997, October). Education forum: England's performance in the Third International Mathematics and Science Study (TIMSS): Implications for educators and policy makers.

Solomon, R., & Aikenhead, G. S. (1994). STS education: International perspectives on reform. New York: Teachers College Press.

South Carolina State Department of Education, Columbia. (1990). BSAP Science teaching through inquiry. Columbia: Columbia Office of Research.

Stahl, R. J. (1996). Cooperative learning in science: A handbook for teachers. New York: Addison-Wesley Publicating Company.

Steffe, L. (1990). Overview of the action group A1: Early childhood years. In L, Steffe. & T, Wood (Eds). Transforming early childhood mathematics education: An international perspective. Hillsdale: Lawrence Erlbaum Press.

Stinner, A. (1995). Contextual settings, science stories, and large context problems: Toward a more humoristic science education. Science Education, 79, (5), 555-81.

Sumeragi, K. (1980, Fall). Issues of Japanese education. Journal of East West Education, 1, (2).

The Sunday Times. (1993, August 29). Parent power: Your guide to choosing the best of education in Britain: Part three: Guide to the National Curriculum. London.

Les systèmes de formation. (1993, 1er-8 Décember). Problèmes èconomiques. no 2352-2353, p. 20-51.

Task Force on Science Policy. (1984, December). An agenda for a study of government science policy. Washington, DC: U.S. Government Printing Office.

Trowbridge, L, & Bybee, R. W. (1990). Becoming a secondary school science teacher. New York: Merill.

Umeno, K. (1990). Environmental issues in the revised national curriculum in Japan. In Proceedings of the 13th Biennial Conference of Asian Association for Biology Education, (pp. 56-74). Seoul: Korean Society of Biology Education.

Umeno, K. (1992). Training teachers to implement the new science curriculum in Japan. In Innovations in science and technology education. Vol. IV. David Layton (Ed). p. 147-158. Paris: Author. (No. [II] ED.91/D.155.4/A).

UNESCO. (1968). International yearbook of education: Vol. XXX. Geneva: Author.

UNESCO. (1977). Education in the Arab states in the light of the Abou Dhabi Conference. Abou Dhabi: Author.

UNESCO. (1978, September). Occasional Paper 31. UNESCO and Environmental Education. ISSN 0317-5693. Ottawa, Canada: Information Section of the Canadian Commission for UNESCO.

UNESCO. (1979). New trends in integrated science teaching. Volume V. Paris: UNESCO. Reay, J: Author.

UNESCO. (1980). The impact of the evolution of exact sciences on the curricula during the next decades. Malitza, M; Sandi, A.; Chitimia, B. (eds). Paris: Author.

UNESCO. (1981). Final report: International Congress of Science and Technology Education and National Development. Paris: Author. (UNESCO doc. ED-81/ CONF. 401/ COL. 10.).

UNESCO. (1983a). Science and technology education and national development. Paris: Author.

UNESCO. (1983b). Statistical yearbook. United Kingdom: Author.

UNESCO. (1984). Interest in science and technology education. Lehrke, M; Hoffmann, L; Gardner, P. L. (eds). Kiel: Institute for Science Education.

UNESCO. (1985a). Final report: International symposium on the teaching of technology within the context of general education. Paris: UNESCO. (UNESCO doc. ED-85/CONF. 809/COL. 21).

UNESCO. (1985b, November). Technology education within the context of general education: Working paper, International Symposium on the Teaching of Technology within the Context of General Education. 18-22 November, 1985, Paris: UNESCO.

UNESCO. (1986a). Innovations in science and technology education. Vol. I. Layton, D. (ed). Paris: Author. (No. [II] ED.85/D.155/A).

UNESCO. (1986b). The social relevance of science and technology education. Document Serie No 18. Paris: Author.

UNESCO. (1986c). Science and technology education and national development. Paris: Author.

UNESCO. (1986d). The place of science and technology in school curricula: A global survey. Paris: Author.

UNESCO. (1988). Innovations in science and technology education. Vol. II. Layton, D. (ed). Paris: Author. (No. [II] ED.87/D.155.2/A).

UNESCO. (1990a). New trends in integrated science teaching, volume VI.. Paris, France. (ERIC Document Reproduction Service No. ED 347 054).

UNESCO. (1990b). Innovations in science and technology education. Vol. III. Layton, D. (ed). Paris: Author. (No. [II] ED.89/D.155.3/A).

UNESCO. (1990c). Science education worldwide. Morris, R. (Ed). Paris: UNESCO. (No. [II] ED 89.D.176-A).

UNESCO. (1991a). World Education Report- 1991. Paris: Author.

UNESCO. (1991b). Needs assessment mission in the field of education and cultural heritage- Lebanon (8-18 May, 1991). Paris: Author.

UNESCO. (1992). Innovations in science and technology education. Vol. IV. Layton, D. (ed). Paris: Author. (No. [II] ED.91/D.155.4/A).

University of Alabama. (n.d). The Integrated Science Program. (No 35487-0167). AL: Author.

Vohra, F. C. (1987, August). Technology as part of general education. In Riquarts, Kurt (Ed), . Science and technology education and the quality of life: Volume 2: Technology Education: Science-Technology-Society. Proceedings of the 4th International IOSTE symposium on world trends in science and technology education. p. 410-418. Kiel 4-12, August. Federal Republic of Germany: Institute of Science Education.

von Glaserfeld, E. (1990). Environment and communication. In Steffe, L. & Wood, T. (Eds). Transforming early childhood mathematics education: An international perspective. Hillsdale: Lawrence Erlbaum Press.

Waring, Mary. (1982). Trends in biological education in schools in England and Wales. In Wanchoo, V.N. (Ed). World views on science education. (pp. 140-167). New Delhi: Oxford & IBH publishing Co._

Weatley, G. H. (1991). Construcivist perspectives on science and mathematics learning. Science education 75 (1), 9-21.

Weiss, I. R. (1994). A profile of science and mathematics education in the United States: 1993. Chapel Hill, NC: Horizon Research, Inc.

West, L. H., & Pines, A. L. (1985). Cognitive structure and conceptual change. New York: Academic Press.

Whitaker's Almanack 1996. (1996). Education. London: J. Whitaker's & Sons LTD. p. 433-447.

White, M. (1986). The Japanese educational challenge. A commitment to children. New York: The Free Press.

Yager, R.E. (1990, April-May). The Science/Technology/Society movement in the United States: Its origins, evolution, and rational. Social Education, 54, (4), 198-201.

Yager, R. E. (1991, September). The Constructivist Learning Model. Towards real reform in science education. Science Teacher, 52-56.

Yager, R.E. & Tweed, P. (1991, November/December). Planning more appropriate biology education for schools. The American Biology Teacher, 53, (8), 479-483.

Zais, R. S. (1976). Curriculum principles and foundations. New York: Harper & Row, Publishers Inc.

Za'rour, G. (1983). Promotion of the endogenous development of science and technology education research and development. In Proceedings: Mathematics and science education in the elementary and intermediate cycles in Lebanon, (pp. 9-15). A conference sponsored by the Science and Mathematics Education and Extension Programs: November 18-19, 1983. Beirut, Lebanon: American University of Beirut.

Zogheib, L, & Habib, H. (Eds). (1983). Methode d'enseignement des sciences au cycle moyen. [Science teaching methods at the lower secondary level]. Unpublished master's thesis, Lebanese University, Lebanon.

Zouain, G. (1994). Lebanon: System of education. In The International Encyclopedia of Education, Vol. 6 (2nd ed.) (pp. 3349-3356). T. Neville Postlethwaite, Great Britain: Elsevier Science Ltd.

Appendices (A -G)

Appendix A

Age	Pattern I	Pattern II	Grade
17	Physics I	Advanced placement or Honors: Biology, Chemistry, Physics	12
16	Chemistry I	Physics	11
15	Biology I	Chemistry I	10
14	Physical science	Earth science or Biology	9
13	Earth and space	General or Integrated science	8
12	Life Science		7
11	Elementary school science		6
10			5
9			4
8			3
7			2
6			1
5			K

Figure 2.

Two Common Patterns of Science Curriculum in the U.S.A.

(Jacobson, 1986; Miller, 1986).

Appendix B

The Content and Structures of the Science Courses Offered at Secondary Level

Science Content in the U.S.A.

The content of life science offered at grade 7.

1) biology: cell structure and function, diversity of life, plants, structures and function, animals' organs and systems, and reproduction;
2) personal health: food, diet, illness and disease, topics dealing with drugs, narcotics and alcohol; and
3) ecology and conservation: cycles in nature, natural environment, environmental impact, air pollution, water pollution, packaging, habitats, preservation of habitats, local flora and fauna.

The content of earth science offered at grade 8.

1) structure of the earth system: composition, and rock and water cycle;
2) earth's history: earth processes, and fossils;
3) earth in the solar system: motions of the moon and the planets;
4) motion and forces; and

5) transformations of energy: heat, light, chemical, electrical, and mechanical energy.

<u>The content of physical science offered at grade 9.</u>

1) environmental science: energy resources: finite and non-finite energy' interactions of energy and matter;
2) geology: constitution of the earth and physical geography;
3) physics: measurement, magnetism, dynamics, changes of state, and static and current electricity; and
4) history and philosophy of science: nature of science such as the stages of the scientific method.

<u>The content of biology offered at grade 10.</u>

1) cell structure and function, transport of cellular material, and cell metabolism;
2) concept of the gene, diversity of life, metabolism of the organism, regulation of the organism, and coordination and behavior of the organism;
3) reproduction and development of plants; reproduction and development of animals, human biology;
4) biological evolution, interdependence of organisms;
5) the nervous system and the behavior of organisms; and

6) personal health and nutrition such as: food, diet, and nutrition; exercise and recreation; illness and disease, injury and first aid; and drugs, narcotics and alcohol.

<u>The content physical science offered at grade 11.</u>

1) chemistry: structure of atoms and molecules, chemical and physical properties of some elements and components that are found in the environment, structure of the periodic table and the characteristics of the various elements found in this table, chemical reaction, synthesis of new compound and basic concepts of nuclear science;
2) physics: form and transfer of energy, mechanics (forces, motion, acceleration), heat and heat transfer, electricity and electro-magnetism;
3) earth science: dynamic system of the earth, rocks and their classification, tectonics plate and the physical feature of the earth, weather and climate and their influences by physical factors; and
4) astronomy: principles of astronomy, the study of stars, galaxies, the solar system, and the interaction of the moon and the earth, and space exploration.

(AAAS, 1993; IEA, 1988; Miller, 1986; IAEP, 1992).

Science Content in the U.K.

The content of integrated science offered in the first year of secondary school.

1) the historical development of scientific principles and theories (Darwin's theory of evolution, Newton's law of motion; medicine through time);
2) simple introduction to astronomy, earth science and microbiology;
3) environmental science, energy resources, air pollution (smog, lead, acid rain, asbestos and the greenhouse effect);
4) the study of magnetism and electricity; and
5) and methods and processes of science topics based on the interaction of science with society through the medium of technology based on solar energy problem; practical application to science and its implications for society such as agriculture, brewing, medicine, generation of electricity and a variety of industrial processes such as the recycling of copper.

The content of the integrated science offered in the second year of secondary school.

1) water (purification of water, water-wheel; windmills); machines; life; earth; photography;

2) metal and alloys; chemical and chemical reaction; energy sources;
3) light, classification; waves, color, perception; sound; keeping warm and keeping cool; particles and kinetic theory;
4) science from the environment; fire; rocket; communications; and
5) the study of invertebrates.

The content of science courses offered in the third year of secondary school.

1) physics: changes of states; motion, forces, and waves; energy transfer and the importance of energy from the sun; properties of electric circuits magnets and electromagnets; and electronic devices and their application;
2) chemistry: structure and function of the atom; chemical reaction; metals and non-metals, the Periodic Table;
3) biology: man and his environment; general plant and animal biology; human health and protection; characteristics of disease and disease prevention; variation among living things; nature of vision; hearing and hearing defects; control of noise in the environment;
4) earth science: cycling of materials; classification of waste biodegradable or non-biodegradable; and
5) weather and climate, meteorology; origin and accumulation of fossil fuel; and the study of the solar system

(DESWO, 1988; Science, Education, Newsletter, 1988).

Science Content in Japan

The content of the school science at the lower secondary school.

1)	Grade 7	Field 1:	substances and their reactions; force, substances and atoms;
		Field 2:	kind of living things and their life; motion of the earth;
2)	Grade 8	Field 1	electric current;
		Field 2	construction of bodies of living things, and changes in weather;
3)	Grade	Field 1	substances and ions; motion and energy;
		Field 2	mutual relationship between living things, the earth's crust and its changes, and human being and nature.

The content of Science I offered in grade 10.

1) force and energy: force and motion, the motion of a falling body, work and heat, transformation and conservation of energy;
2) composition and change of substance: the various units which compose substances, elements, amount of substance, the mole, quantitative relations in chemical reactions;
3) evolution: the cell and its division, reproduction and generation, heredity and variation, evolution of living things;

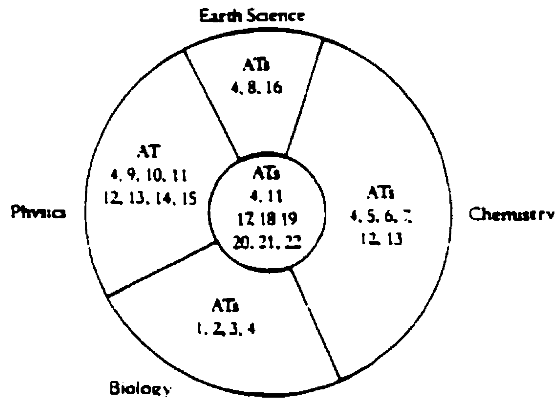
4) the balance of the natural world: the motion of the earth, form and state of the earth, incoming and outcoming radiation, ecosystems and the circulation of matter; and

5) human beings and nature: natural resources, solar energy, the utilization of nuclear power and the preservation of the natural environment.

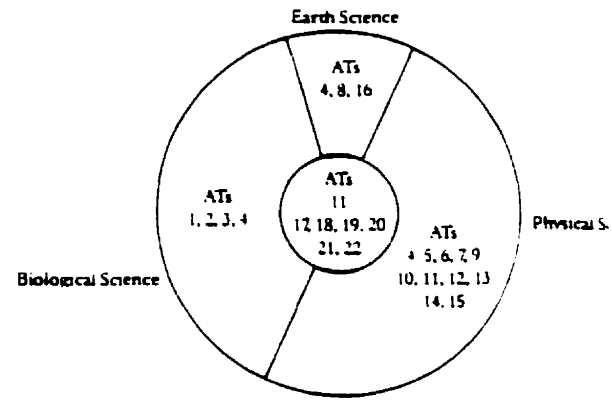
(Ministry of education, Science and Culture, 1983a, 1989a; Nogami, et al. 1987)

Appendix C

Model 1 A Co-ordinated Science

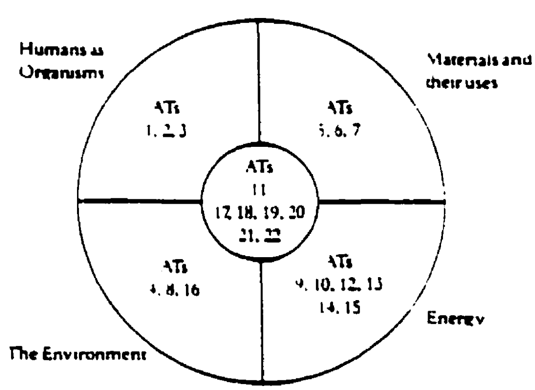


Model 2 Physical Science and Biological Science

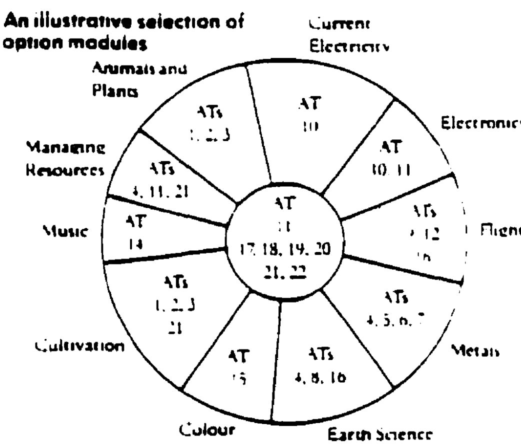


Model 3 Modular Science (core + options)

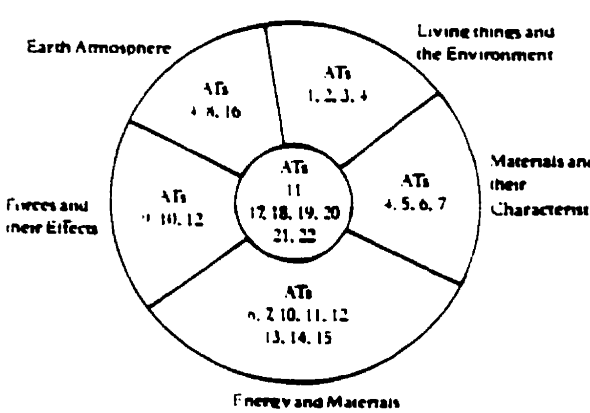
Core Modules



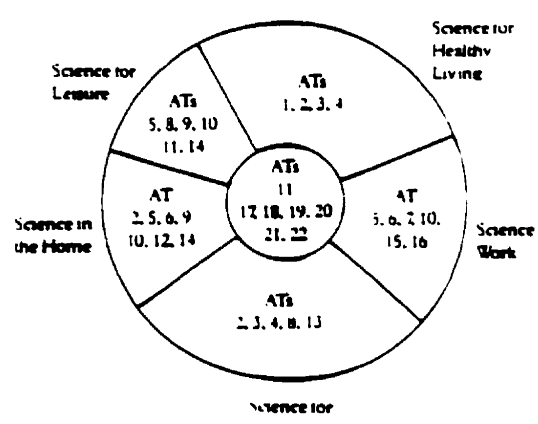
An illustrative selection of option modules



Model 4 An Integrated Science



Model 5 Science in everyday contexts



Attainment Targets and Models of Organization

(Source: DESWO, 1988).

Appendix D

Science Subjects and Contents Planned for the Advanced Students in Science

The content of science subjects in the U.K. for years 4 and 5

1) the variety of life: population growth, density and control; food production; cycling of elements;
2) processes of life: anatomy and function of the major organs of living things; factors that affect life (hygiene, diet, drugs, and alcohol abuse); energy transfer and life processes; reproduction, growth and technology supporting life;
3) genetics and evolution: variations, basic principles of inheritance and inherited diseases; and the basic principles of genetic engineering;
4) human influences on the earth: effects of human activity on the earth; and ecological issues facing society;
5) types and uses of materials: changes of states and matters; their structure and properties; periodic table; and the limitation of systems of classification.;
6) making new materials: chemical reaction and biochemical change; and social and environmental implications of industry;
7) explaining how materials behave: kinetic energy, structure of the atom, and radioactivity and its effect on matter;

9) earth and atmosphere: structure of the earth and geological changes; and the development of the atmosphere;

10) forces: the effect of forces on motion; and applications of hydraulics (rockets and jet propulsion);

11) electricity and magnetism: production, measurement, transfer and uses of electrical energy; and thermionic emission and the production of X-rays;

12) energy transfer: transfer by conduction, convection and radiation;

13) information transfer: communication systems; and methods of coding, transmitting and storing information;

14) energy resources: renewable and nonrenewable energy;

15) sound and music: wave motion and its frequency; characteristics and effects of vibration in mechanical systems;

16) using light: electromagnetic family of waves and their uses in domestic situations, communication, and medicine;

17) the earth in space: gravitational force and the solar system (DESWO, 1988; NCC, 1989a).

The content of science subjects in Japan for advanced students

In Japan students can easily reach their senior year before having any option. After the integrated science course (Science I) is completed in grade 10 at the upper secondary level the last compulsory science course for secondary schools in Japan, students can continue with Science II or begin to study the traditional science disciplines such as biology, chemistry, physics, and earth science.

The content of physics.

1) force and motion (various kinds of motion, momentum, motion of gaseous molecules);
2) wave motion (properties of waves, sound waves, light waves);
3) electricity and magnetism (electric fields, electric current, electric current and magnetic field, electromagnetic induction, and alternating current); and
4) atoms (electrons and light, atoms and atomic nucleus).

The content of chemistry.

1) chemical properties of substances (inorganic substances, organic compounds, polymers);
2) state of substances (pure substances, mixtures);
3) chemical reactions (rates of reaction, chemical reactions and associated heat, chemical equilibrium, reactions between acids and bases, oxidation-reduction reaction); and
4) structure of matter (structure of an atom, chemical bond).

The content of biology.

1) formation of a bio-organism (formation of cells and tissues, development and morphogenesis);

2) living bodies and energy (metabolism and energy transfer, genes and appearance of characteristics);

3) homeostasis and regulation (animal behavior, homeostasis and regulation of individuals); and

4) biotic communities (organization of biotic communities, changes in biotic communities).

The content of earth science.

1) structure of the earth (earth as a planet, atmosphere and oceans, earth's internal energy);

2) history of the earth (strata, the earth's crust, evolution of the earth, geological features of the Japanese Islands); and

3) structure of the universe (the sun, permanent stars, the galaxy and the universe).

(Ministry of Education, Science, and Culture, 1983b).

Appendix E

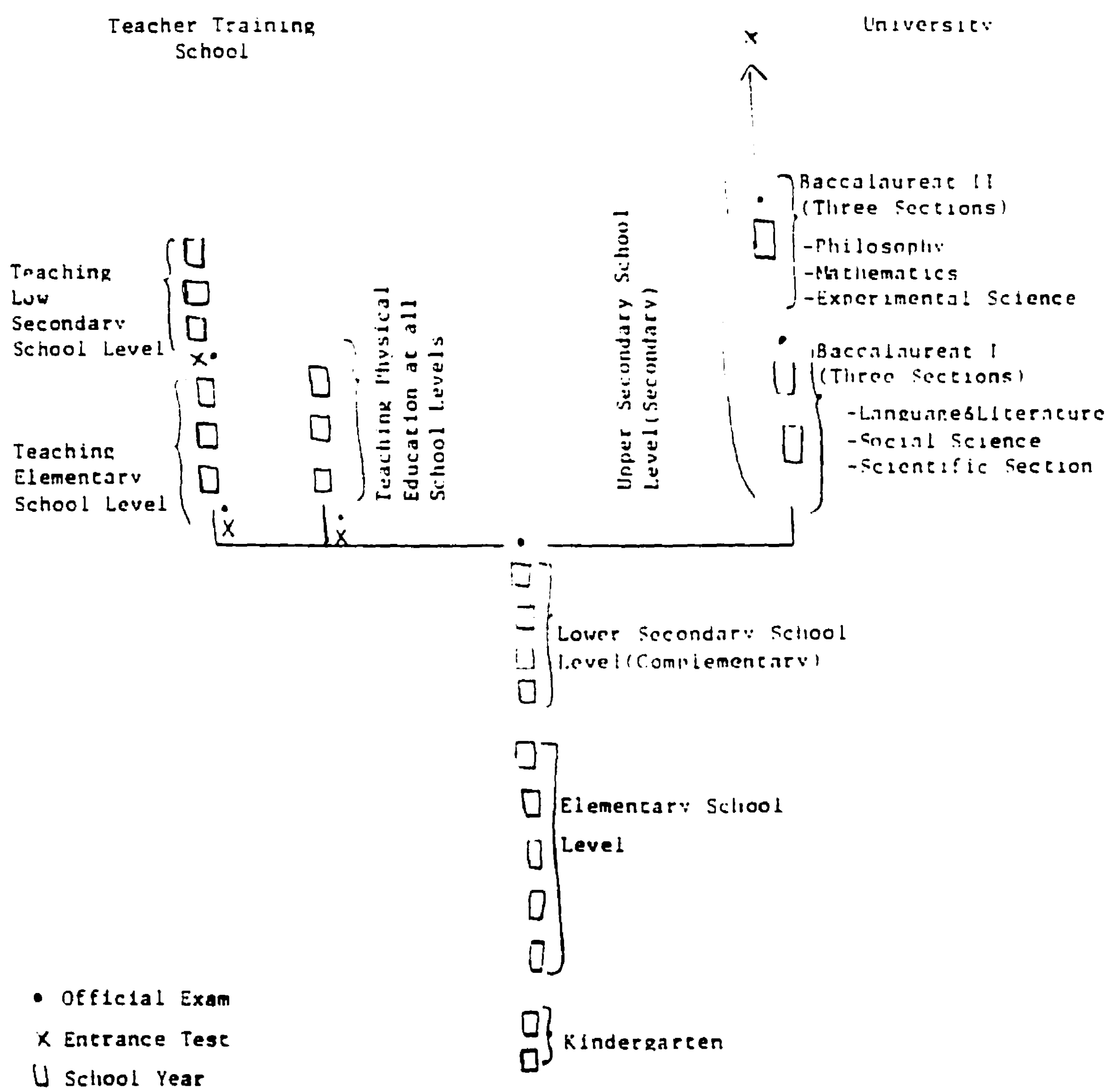


Figure 4. School Educational System

(Source: Bashour., 1979, p. 130-131).

Appendix F

The Content and Structures of the Science Courses Offered at Secondary Level in Lebanon

SCIENCE I
PHYSICAL SCIENCE

I — Heat energy

1. Fire

Conditions necessary to have a fire. The role of fuels, oxygen, and kindling temperature.

The compositions of fuels such as coal, butagas, kerosene, gasoline and diesel oil.

Chages that take place during combustion.

Precautions to be taken in the use of fire, and the importance of keeping fire under control.

The different ways of putting out a fire.

The major causes of uncontrolled fires : negligence and faulty gas connections, improper storage of flammable materials, faulty heating and electrical equipment and spontaneous combustion.

2. Temperature and Heat

Expansion of liquids, gases, and solids.

Different types of thermometers

Alcohol or mercury thermometer

Air thermometer

Metallic thermometer.

The measurment of heat

Human body temperature and the clinical thermometer

Conductors and insulators

Precautions to be taken in utilizing extremely cold and hot objects.

II — Water and its solutions

1. Water

Importance and properties of water.

Different sources of drinking water.

Occurrence of water in solids.

Treatment of water for drinking purposes.

Ice, water and steam representing three states of matter.

Evaporation and condensation.

Density, freezing and boiling points of water and its use as a standard.

Composition of water — Electrolysis.

2. Solutions

Water as a universal solvent.

Other solvents.

Changes that take place when different materials dissolve in water.

The sea as a huge water solution.

Salt from the sea.

Filtration, distillation and crystallization.

Acidic and basic solutions, indicators, and neutralization.

III — Science and the scientists

How are advances made in science ?

What are the similarities and differences between an ordinary person and a trained scientist ?

The role of observation in science.

Measurement of length and weight.

The solution of a problem in a scientific and in a non-scientific manner.

IV — Force and machines

Force : definition and simple illustrations of mechanical force.

Operational definition of work, energy and power.

Simple machines such as the inclined plane, levers and pulleys.

Rockets, jets and propellers.

V — The phenomenal aspects of light, sound, magnetism and electricity

1. Light and Sound

Speed of light and of sound.
Reflection and Refraction.
Lenses, prisms, color.
Musical sounds and instruments.
Proper lighting.

2. Magnetism and Electricity

Magnets and their basic properties.
Simple electrical circuits.
Electrical measurement, lighting and heating
House circuits and safety measures.
Factors in the utilization of electrical equipment that affect the electricity bill.

SCIENCE II
NATURAL SCIENCE

I — Diversity among animals

1. Diversity in animal habitats such as :

The seashore, the mountain, fresh water, the sea, the forest, the desert, the plain, the city, ...

2. Morphological variation among animals :

- Body size, body cover and color, body form, locomotion, skeleton, denture, digestive organs, respiratory organs, ...
- Relation of these variations to the way of life and environment.
- Examples to be taken from among those animals found in Lebanon or similar ones. Such as cat, dog, cow, horse, rabbit, hen, lizard, fish, frog, butterfly, cricket, ant, fly, crab, spider, tapeworm, earthworm, snail, sea urchin, sea anemone and commercial sponge, paramecium and microorganisms, ... (It is advisable to name similar animals.)

3. **Classification of animals**

A brief summary classification of the animal kingdom to illustrate general bases and similarities, and the need for classification in science.

4. **Development of Animals**

The development of the chick embryo, the frog, and an insect.

II — **Diversity Among Plants**

1. **Observation and identification of local plants with reference to plant habitats.**

2. **Morphological Variation Among Plants :**

- Flowers, leaves, roots, stems, and a notion of their functions.
- Examples to be taken from locally common plants such as : apple, orange, olive, almond, bean, lentil, onion, cyclamen, sugar-cane, banana, tomato, tobacco, pine, cedar, fern, moss, mushroom, algae, bacteria, viruses, ... (It is advisable to name similar plants.)

3. **A brief summary classification of plants**

SCIENCE III
MAN AND HIS ENVIRONMENT

I — **The Physical environment**

1. **The Earth**
   - The Earth and its surface
   - Minerals within the earth
     - Classification of minerals
     - Mineral properties
   - Petroleum : origin, layers, extraction
   - Origin and classification or rocks
   - Interior of the Earth
     - Earthquakes
     - Layers of different seismic behavior
     - Crustal movement
   - Weathering
   - Erosion
   - Stratigraphy
     - Age of soils
     - Geological eras
     - Study of some fossils of Lebanon
   - Oceans
     - Characteristics of oceans
     - Tides and waves
     - Sediments on the ocean floor.
2. **The Atmosphere**
   - The nature of the atmosphere
   - Measuring the properties of the atmosphere
   - Movement of the air and the weather
   - Forecasting the weather
   - Clouds, precipitation and colors in the sky

3. **The Universe**

The solar system

The moon, stars, galaxies, and the universe

Measuring the universe

Distances to the stars

Stellar parallax

Apparent and absolute magnitudes

Space exploration

Rockets

Satellite orbits

Escape velocity

Man and space travel.

II — **The living environment**

1. **Habitats and Communities**

Ecosystems

Life in water : fresh water : sea water

Life on land

General problems of life on land

A study of a community like forest, grassland, desert, ...

2. **The balance of nature**

Cycles

The carbon-hydrogen-oxygen cycle

The nitrogen cycle

Interaction between organisms and their environment

Foods webs

Colonization and succession

3. **Man and the Balance of Nature**

Man and his diet

Human population and food supply

Man's needs of food : Proteins, Enzymes, Vitamins.

How green plant make food

Food shortage today

How man increases food supply

Man's influence on living resources

Biological control of pests

Pollution

SCIENCE IV
LIFE SCIENCE

I — Cells : Basic Structure of living things

1. The microscope : Structure and use.
2. The cell theory : plant cells, animal cells, size of cells.
3. Physiology of cells : The parts of cells ; generalized cell structure ; enzymes, energy for the cell.
4. Reproduction of cells : Mitosis ; meiosis.

II — How our bodies work

1. The Body Framework and Movement :
   Bone and muscle tissues ; functions. structure and principal types ; joint types ; bone fracture.
2. The Foods we Eat :
   Types of food compounds and their use in the body ; vitamins and food groups.
3. Digestion and Absorption :
   Digestive system ; digestion ; enzymes and glands ; absorption.
4. Blood Circulation :
   Blood vessels ; the heart ; blood composition and circulation ; circulatory troubles ; transfusion of blood.
5. Lungs and Breathing :
   Structure of the lungs ; breathing ; respiratory diseases.
6. Excretion :
   Excretory system ; the skin ; regulation of temperature.
7. Body Controls :
   Nervous system ; reflex activity ; eyes and ears ; some endocrine glands and hormones.

III — Bacteria and Health

1. Bacteria and Disease :

   What are bacteria ? Some kinds of Bacteria ; Robert Koch and tuberculosis ; Louis Pasteur and fermentation.

2. Body Defenses against Disease :

   Where germs enter the body ; how body keeps out germs ; immunization.

3. Stopping the Spread of Diseases :

   Epidemics ; quarantine ; examples on community action ; carriers of diseases ; some large parasites.

4. Building of Health :

   Change in length of life ; some causes of poor health such as smoking, alcohol, malnutrition. ...

IV — Genetic continuity

1. Inheritance of traits in plants and animals.
2. Heredity and environment.
3. Chromosomes.
4. Genes.

SCIENCE IV
NATURE OF MATTER

I — Kinetic Molecular Nature of Matter

1. Properties of matter
2. Particle nature of matter.
3. Kinetic Theory of matter
    - Properties of solids
    - Properties of liquids
        - Cohesion and adhesion
        - Surface tension
    - Pressure exerted by a liquid
    - Capillarity
    - Specific gravity
    - Properties of gases
        - Diffusion
        - Pressure exerted by a gas
        - Boyle's law
    - Thermal expansion
    - Change of state

II — The structure of matter

- The structure of the atom
- Elements and compounds
    - Valence and molecular formulas
    - Study of the preparation and properties of oxygen and hydrogen
- Atomic and molecular weights
- Laws of chemicals reactions
- Radioactivity and artificial radiation

III — Carbon compounds

- Carbon and bicarbonates
- Carbon dioxide and carbon monoxide
- Hydrocarbons
- Saturated and unsaturated hydrocarbons
- Organic acids
- Amines
- Carbohydrates

Appendix G

Science Subjects and Contents Planned for the Advanced Students in Science In Lebanon

PHYSICS

FIRST YEAR

Literary and Scientific Sections

MECHANICS :

Notion of force ; units : kg-force and newton. Experimental study of the composition of forces ; resultant : concurrent forces ; parallel forces. Couples and moments.

A simple notion of equilibrium.

Measurement of weight : balances ; qualities of balances ; double weighing.

Work done by a force constant in magnitude and direction ; units ; simple machines ; principle of conservation of work.

Elementary notion of friction.

Notion of power ; units : watt and kgf-m per sec.

Notion of pressure ; units : newton-m^{-2}.

HYDROSTATICS :

Definition of a fluid ; liquids and gases.

Pressure exerted by a fluid in equilibrium :

a) at a point on the surface of the container.

b) at a point within the fluid.

Difference in pressure between two points in a fluid in equilibrium.

Pascal's law ; applications.

Archimedes' principle. Floating bodies.

Specific gravity and density.

Atmospheric pressure ; the barometer ; the manometer.

Compressibility of gases ; Boyle-Mariotte's law.

HEAT :

Calorific phenomena : temperature

Expansion of solids : coefficients of linear and cubical expansions.

Thermometers : graduation ; themometric scales.

Effects of the change in temperature of a gas at

a) constant pressure.

b) constant volume.

Sources of heat.

Notion of quantity of heat : specific heat ; heat capacity ; calorimetry.

EXPERIMENTS :

- • 1. Measurement of lengths, surface and volumes. Precision of measurement .
- 2. Graduation of a spring balance.
- • 3. Composition of concurrent and parallel forces.
- 4. Locating the centre of gravity.
- • 5. Methods of weighing : double weighing ; Gauss' method.
- 6. Specific gravity of solids — Specific gravity bottle method. Archimedes' principle method.
- 7. Specific gravity of liquids
- • 8. Study of an inclined plane.
- • 9. Verification of the Boyle-Mariotte's law.
- 10. Expansion of a solid.
- 11. Checking the fixed points on a thermometer.
- 12. Measurement of the quantity of heat : calorimetry.
- • 13. Measurement of specific heat : water equivalent of a calorimeter.

Remarks :

1. An experiment can be made in one or more sessions.
2. Students are to perform a minimum of eight experiments per year, giving preference to those marked with an asterisk (•).

SECOND YEAR

Literary Section

OPTICS :

Rectilinear propagation of light : shadows.

Laws of reflection : plane mirrors : images : applications.

Laws of refraction : absolute index of refraction : total internal reflection.

Spherical thin lenses : experimental study . practical applications : the magnifier -- the reduced eye — the camera.

MAGNETISM :

Magnets . poles . magnetic masses . Coulomb's law . magnetic field : induction vector : lines of force . magnetic spectrum.

ELECTRICITY

An experimental study of the electric current based on its effects : conventional direction of a current.

MAGNETIC EFFECTS :

Action of a magnetic field on a current. Laplace's law.

Intensity of a current . the ampere . quantity of electricity.

Moving coil galvanometer : ammeter.

CALORIFIC EFFECTS :

Heat liberated by the passage of a current through a conductor.

Joule's law . electric resistance . the ohm . applications.

ELECTRIC ENERGY .

Notion of electric energy . difference of potential between two points of a circuit . the volt.

Generators . E.M.F.

Receivers . counter E.M.F.

Ohm's law and laws of currents in derivation . applications : voltmeter.

CHEMICAL EFFECTS :

Electrolysis : Faraday's laws.

Polarisation. Description of a cell and an accumulator.

EXPERIMENTS :

- • 1. Measurement of indices of refraction.
- 2. Focometry of thin converging lenses.
- • 3. Measurement of heat liberated by Joule's effect.
- 4. Measurement of electric resistance
- • 5. Measurement of E.M.F.
- 6. Verification of Faraday's laws

Scientific Section

OPTICS :

Optical phenomena : Sources of light , self-luminosity and luminosity by diffuse reflection. Illuminated objects.

Rectilinear propagation of light. Shadows.
Laws of reflection.

Plane mirrors . march of rays . images . rotating mirrors ; applications.

Spherical mirrors (Gauss' aproximations) , march of rays ; construction of images ; formulae ; applications.

Laws of refraction:
Passage of light from one transparent medium into another ; velocity of ligth ; absolute index of refraction . total internal reflection.

Dioptre plane . images (Gauss' approximations) , formulae.
Plate with parallel faces : march of rays . images (Gauss' approximations) . formulae.
Prism : march of monochromatic rays in a principal section. conditions of emergence . experimental study of deviation.
Spherical thin lenses . different types : march of rays (Gauss' approximations) . foci . optical centre : construction of images . formulae.

Convergence . theorem of convergence of thin lenses in contact.
Focometry.
Camera.

The eye and vision . a summarized study of the constitution and the functioning of the eye ; the reduced eye . accommodation ; defects in accommodation . separating power of the eye.

Optical instruments : principles ; focusing ; magnifying power ; magnification.

The magnifier.
The microscope.
The astronomical telescope and the Galilean telescope.

MAGNETISM :

Magnets, poles : magnetic masses ; Coulomb's law ; magnetic field : magnetic spectrum ; lines of force ; uniform field ; flux.

Terrestrial magnetic field ; inclination ; declination ; horizontal component : the compass.

ELECTRICITY :

An experimental study of the electric current based on its effects ; conventional direction of a current .

MAGNETIC EFFECTS :

Action of a magnetic field on a current ; electromagnetic force ; Laplace's law . electromagnetic definition of the intensity of a current ; the ampere : quantity of electricity ; the electromagnetic balance ; electromagnetic work.

Moving coil galvanometer.

Magnetic field of a current : spectrum . expression of the induction vector of an infinitly long rectilinear current, at the centre of a coil, and at a point on the axis of a solenoid of infinite length.

Principle of the moving magnet galvanometer.

CALORIFIC EFFECTS :

Heat liberated due to the passage of a current through a conductor.

Joule's law electric resistance of a conductor ; the ohm.

Applications.

ELECTRIC ENERGY :

Notions of electric energy.

Potential difference between two points of a circuit . the volt ; generators : electromotive force.

Receivers : counter-electromotive force.

Ohm's laws.

Currents in derivation : applications

CHEMICAL EFFECTS :

Electrolysis . qualitative and quantitative laws of Faraday.

Polarization of voltameters : principle of cells and accumulators.

ELECTRIC MEASUREMENTS :

Measurement of intensities and electromotive forces.

Interpretation of electric phenomena by the electronic theory.

Conductivity of metals and solutions.

EXPERIMENTS :

1. Propagation of light — umbras — peaumbras.
2. Reflection of light — rotating mirrors.
3. • Verification of the formula of spherical mirrors.
4. Refraction -- measurement of indices (liquids — solids).
5. Experimental study of a plate with parallel faces.
6. • Prism : measurement of its angle and of the angle of deviation ; curve of D = f (i) ; minimum deviation.
7. • Focometry of converging lenses.
   (direct method — Bessel's method -- Silberman's method — autocollimation method).
8. Focometry of diverging lenses.
9. Study of the microscope illuminated chamber.
10. Study of a telescope mounted on an optical bench.
11. • Magnetometer : comparison of magnetic fields.
12. Magnetic spectrum.
13. Tangent compass.
14. Measurement of heat liberated due to Joule's effect.
15. Verification of the law $R = \rho \frac{l}{s}$ for a uniform conducting wire.
16. • Measurement of electric resistance by the metre bridge.
17. • Measurement of E.M.F. by the potentiometer method.
18. Counter E.M.F. and resistance of a voltameter.
19. Verification of Faraday's laws.
20. Study of cells.

Remarks :

1. One fore sessions can be assigned for one experiment.
2. Students are to perform 12 experiments per year. Giving preference to experiments marked with an asterisk.(•).

THIRD YEAR
Philosophy Section

Principles of dynamics . their application to rectilinear motion . free fall.

Notion of mass : units of mass and force.

Notion of mechanical energy : potential and kinetic energy.

Principle of equivalence of work and heat. Measurement of the mechanical equivalent of the calorie.

Periodic motion. Pendular motion : simple pendulum.

Vibratory origin of sound.

Experimental study of the propagation of vibratory motion : wavelength. Speed of sound.

Reflection of waves. Standing waves . application to sound tubes and vibrating strings.

Definition of the physiological qualities of sound : its physical interpretation

Interference of light.

Electro-magnetic induction. Self-induction.

Elementary ideas about alternating currents : effective intensity ; effective potential difference.

Transportation of electrical energy : principle of the transformer.

Electronic emissions : thermoionic effect : diode. Photoelectric effect Planck's constant. Cathode rays. X-rays.

Simple notions of the constitution of matter : the atom and the nucleus.

Different forms of energy : principle of conservation of energy.

EXPERIMENTS :

Free fall : vibrating blade.

Principles of dynamics : (Atwood's machine. inclined plane. Fletcher's trolley...).

Stationary waves : (Melde's experiment. Kundt's tube).

Measurement of J.

Simple pendulum.

Interference of light.

Sections of Mathematics and Experimental Sciences

Notion of approximation of physical measurements.

Precision in numerical calculations.

DYNAMICS :

1. Experimental study of the dynamics of rectilinear motion. Free fall.
   Fundamental law of dynamics. Definition of mass and momentum. Units.
   Applications sinusoidal rectilinear motion ; air resistance ; limit velocity.

2. Study of curvilinear motion in a plane.
   Velocity vector and acceleration vector ; tangential and normal accelerations.
   Vectorial expression of the laws of dynamics of a point and of systems :
   Momentum
   Angular momentum
   Theorem of kinetic energy.
   Forces due to a potential field.

   Applications :

a) Motion of a point circular motion (uniform and sinusoidal). projectile motion, motion due to Newtonian attraction.

b) Motion of a solid : moment of inertia ; torsion pendulum ; pendulum ; collisions . rocket . gravitational field ; variation of g with altitude.

3. Measurable magnitudes : fundamental and derived units. Coherent systems of units Dimensional equations.

HEAT ;

Principle of equivalence of heat and work. Measurement of J.

Notion of internal energy.

Change of state : vaporisation , fusion. Liquid-vapour equilibrium curve : latent heat of change of state.

Principle of the steam engine, the internal combustion engine and the refrigerator : diagrams.

Efficiency of heat engines. Statement of Carnot's principle and theorem.

VIBRATORY MOTIONS :

Propagation of vibratory motion. Wavelength. Composition of two vibratory motions. Interference. Reflection of waves.

Standing waves. A simple notion of resonance.

Application to sound tubes and vibrating strings.

OPTICS ;

Failures of geometrical optics. Examples of diffraction.

Hypothesis of luminous vibration. Principle and experimental verification of interference of light.

Dispersion of light : the spectroscope (prism or diffraction grating) using visible light : emission spectrum.

ELECTRICITY ;

Simple notions of electrostatics . electric charges . Coulomb's law ; electric field.

Condenser with parallel faces . capacity . the farad.

Electromagnetic induction . experimental study . E.M.F. of induction . Lenz's law. Self-induction . the henry.

Simple notions of alternating currents ; production and properties ; transportation of electrical energy . principle of the transformer. Effective intensity and potential difference. Average power.

Ohm's law applied to alternating currents : influence of self and of capacity. Power factor.

Thermoionic effect : diode.

Cathode rays . the electron. X-rays.

Photoelectric effect . Planck's constant.

Different forms of energy. Principle of conservation of energy.

An idea of the constitution of matter : the molecule, the atom and the nucleus.

Natural and artificial radioactivity . half life.

Nuclear reactions : fusion. Nuclear energy.

EXPERIMENTS :

1. Measurement of lengths, surfaces and volumes. Calculation and approximation.
* 2. Measurement of specific gravity. Comparison of results obtained by different methods.
3. Verification of the laws of free fall (vibrating blade...)
* 4. Verification of the laws of dynamics (Atwood's machine, inclined plane...)
5. Centrifugal force.
* 6. Study of pendulums : simple, Kater's, torsion...
7. Study of the motion of a spring.
* 8. Measurement of J.
9. Verification of the theorem of kinetic energy.
* 10. Standing waves in a vibrating string
11. Resonance in a tube.
12. Kundt's tube.
* 13. Study of a set-up producing interference of light.
14. Study of a capacitor.
* 15. Measurement of the frequency of an alternating current.
16. Measurement of a self and of a capacity.
17. Resonance in an electric circuit.

Remarks :

1. An experiment can be made in one or more sessions.
2. Students are to perform a minimum of twelve experiments per year, preference being given to those marked with an asterisk (*).

CHEMISTRY

FIRST YEAR

Literary Section

Lectures demonstrations and Laboratory work.

I — Homogeneous mixtures, heterogeneous mixtures, pure substances.
Compound substances, simple substances, notion of the element.
Molecules, atoms, symbols.

II — The nucleus, the proton, the electron, electronic shells.
Atomic number. Avogadro's number, gram-atom, mole.
Classification of the elements into families according to their electronic configurations.

III — *Chemical Bonding :*
Ionic bonds
Covalent bonds.

IV — *Changes of matter :*
Physical changes.
Chemical changes, conservation of matter.
Nuclear changes.

V — Symbols, formulae, equations.
Elements of nomenclature.
Avogadro-Ampere's law.

VI — Oxygen

VII — Hydrogen.

VIII — Water.

IX — Carbon, carbon monoxide and carbon dioxide.

Scientific Section

Lectures demonstrations and Laboratory work.

I — Homogeneous mixtures. heterogeneous mixtures. pure substances. Compound substances. simple substances. notion of the elements. Molecules. atoms. symbols.

II — *Structure of the Atom :*
The nucleus. the proton. the neutron. the electron. electronic shells. Atomic number. mass number. isotopes. atomic weight. Avogadro's number. gram-atom. mole.

III — Electronic configuration and the periodic classification of the elements. Atoms and ions. atomic radii and ionic radii.

IV — *Chemical bonding :*
Ionic bonds.
Covalent bonds.
Coordinate bonds.

V — *Changes of matter :*
Physical changes.
Chemical changes. Conservation of matter.
Nuclear changes. Matter and energy.

VI — Symbols. formulae. equations.
Elements of nomenclature.
The Avogadro Ampere law . calculation of compositions by mass and volume.

VII — Oxygen

VIII — Hydrogen.

IX — Water : heavy water.

X — Carbon . carbon monoxide and carbon dioxide. The carbon family.

SECOND YEAR

Literary Section

Lectures demonstrations and Laboratory work.

I – Ions.

II – Acids, bases and salts. Volumetric analysis.

III – Oxidation — reduction.

IV – Chlorine and hydrochloric acid.

V – Sulphur and sulphuric acid.

VI – Sodium and sodium hydroxide.

VII – Calcium carbonate, calcium oxide and calcium hydroxide.

VIII – Aluminum.

IX – Iron.

Scientific Section

Lectures demonstrations and Laboratory work.

I – Properties of solutions ; crystals and crystallization.

II – Theory of ionization.

III Acids, bases and salts.

IV – Oxidation – reduction.

V – Volumetric analysis.

VI – The halogens. Chlorine, hydrogen chloride.

VII The sulphur family. Sulphur. Hydrogen sulphide, sulphur dioxide, sulphur trioxide, sulphurous and sulphuric acids.

VIII — The nitrogen family, nitrogen, ammonia, nitric acid.

IX — The alkali metals. Sodium and sodium hydroxide.

X – The alkaline-earth metals. Calcium, calcium carbonate, calcium oxide, calcium hydroxide.

XI – Aluminum.

XII – Iron.

XIII – Copper.

THIRD YEAR

Sections of Mathematics and Experimental Sciences

A PHYSICAL CHEMISTRY

I — *Structure of the atom :*

Existence of the atom, nucleus, proton, neutron, electron, (experiments showing the existence of these particles), energy levels (shells and sub-shells). Simple substances and elements.

Atomic number, mass number, isotopes, Avogadro's number, gram-atom, moles.

II — *Natural and artificial radioactivity.*

III — *Chemical bonding :*

Structure of inert gases, electronegativity, ionisation potential, ionic bonds, ionic radii.

Covalent bonds, atomic radii, coordinate bonds, polarity of molecules, metallic bonds, intermolecular bonds or attractions.

IV — *The gaseous state :*

Equation of state of an ideal gas ; diffusion of gases ; Gay-Lussac's law ; Avogadro-Ampere's law ; vapour pressure ; boiling point.

V — *Physical methods for the determination of molecular weights :*

Case of gases and volatile liquids ; case of soluble solids.

Mass spectrography.

VI — *Chemical reactions and energy of reactions :*

VII — *Chemical equilibrium :*

Equilibrium between molecules ; equilibrium constant ; law of Guldberg and Waag.

Le Chatelier's principle.

Ionic equilibria ; dissociation constant ; case of water ; notion of pH.

VIII — *Chemical kinetics :*

Rates of reactions ; factors influencing the rates of reactions ; catalysts.

B - ORGANIC CHEMISTRY

I - Principles of determining the presence of carbon, hydrogen, nitrogen, chlorine, bromine and sulphur.
Principles of quantitative analysis.
Determination of formulae. Functions.

II - General study of the aliphatic hydrocarbons (illustrated by examples from chemistry of methane, ethane, ethylene and acetylene).

III - Aromatic hydrocarbons : benzene.

IV - The alcohol function : common properties of the three classes of alcohols and particular properties of each class.
Preparation.

V - Comparative study of the aldehyde and ketone functions . properties and preparation.

VI - The acid function : properties and preparation . formation, hydrolysis and saponification of esters.

VII - The amine function : definition of the three classes of amines. Common properties of the three classes. Preparation of primary amines.

VIII - Macromolecules general study of their chemical importance.

NATURAL SCIENCES

THIRD YEAR

Philosophy Section

A - GENERALITIES .

1. Cells and Tissues.

- Morphological study of an animal cell and of a plant cell, following the observation of typical examples.
- Study of mitosis, following observations of microscopic preparations.
- State of cellular protoplasm.
- Exchange between a cell and its medium (Vital colouration, plasmolysis, turgidity, selective permeability
- Study of conjunctive and epithelial tissues.
- Study of the parenchima and the conductive tissues.
- Cellular structures as revealed by the electronic microscope (observation of photographic documents).
- Notions of physics and chemistry necessary for the understanding of the physiology of living things, based on simple experiments.
- Real and colloidal solutions, emulsion, suspension, floculation, coagulation, precipitation.
- Tyndall effect.
- Osmosis, diffusion and permeability
- Endothermic and exothermic reactions, oxidation-reduction, unstable products.
- Notion of pH.
- Study of the chemical composition of living substances.

2. Dissection of a mammal and of a flowering plant showing the general organisation of the living organism.

B — ANIMAL BIOLOGY (Zoology)

Technical terms ,historical and morphological knowledge are to be reduced to the minimum necessary for the understanding of physiology.

1. Digestion

- Revision of foods and the general organisation of the digestive system.
- Notion of diastases deduced from an artificial digestion
- Properties of diastases.

Study of the complete artificial digestion of starch and albumen of the white of an egg.

The result of the digestion of different foods

- Simple notion of the absorption of the products of digestion.

2. *Circulation*

- The blood : Preparation and observation of a blood smear.
- The elements that form the blood : structure and role.
- The plasma, composition and role.
- The heart : anatomy and function, following a direct observation of the heart of a frog and the dissection of the heart of a sheep.
- Cardiac automatism.

3. *Respiration*

- Revision of the anatomy of the respiratory system
- Gaseous exchanges in the lungs and in the tissues
- Cellular oxidation and the respiratory diastases

4. *The Nervous System*

- Observation of a transverse section of the spinal cord and of a nerve, leading to the notion of the nerve fibre and the neuron, the white matter and the grey matter, and synapse
- General constitution of the nervous system, following the dissection of a vertebrate (frog) and of a mammalian encephalon (sheep).
- Properties of a neuron (excitability and conductibility). Chemical mediators.

Reflexes :

- Experimental study of patellar reflexes in man, and the medullary reflexes in a frog.
- The anatomical elements of the reflex arc.
- Magendie's experiments and the direction of a nervous influx.
- Importance of reflexes.

The Role of the Cerebrum :

- graphical study and medical observations.
- voluntary movement and conscious sensibility : cerebral localisations.
- conditioned reflexes : performance of an experiment, importance in education.
- The neuro-vegetative system.

5. The Sense Organs

— Anatomy of the eyeball, deduced from the dissection of the eye of a mammal (sheep or ox).

- Observation of a microscopic preparation of the retina.
- The optical mechanism of vision.
- Role of the retina in vision : vision of details, vision of colours, vision in dim and bright light.
- Role of the optic nerve and of the cerebrum in vision.

  Generalisation of the notion of a sense organ : receptor, nerve, nerve centre.

6. The muscles

— Anatomical and histological study of a striated muscle.

  A simple study of its principal properties.

— A graphical study of muscular contraction.

7. The Endocrine glands

— Revision of the different kinds of glands (exocrine and endocrine)

— Notion of hormones.

— A summary of the anatomy and physiology of the thyroid gland.

— Simple notion of other glands and their influence in life.

C PLANT BIOLOGY (Botany)

1. Brief study of mineral nutrition of a green plant.

2. *Organic Nutrition*

Chlorophyllian function

a) Experimental evidence of :

- Liberation of oxygen.
- Absorption of carbon dioxide .

b) Influence of external factors :

Light, CO_2, temperature.

c) Influence of internal factors.

d) The Chlorophyll :

Extraction, separation, properties.

e) Synthesis of Saccharides.

- Deduce the synthesis of other organic substances.

3. *Nutrition of Plants without Chlorophyll (Non-green Plants)*

4 *Respiration in plants*
General Conclusion :

Generalities of the respiratory phenomenon in living things
The carbon cycle

D GENERAL BIOLOGY

1. Revision of the anatomy of the male and female reproductive systems

2. Observation of microscopic preparation of spermatozoons and of ovules of different animals.

3. Simple notion of gametogenesis and fertilization .
   Sexual reproduction deduced from the study and observation of an example of animal life (Sea-urchin)

4. Experimental study and chromosomal interpretation of monohybrid and dihybrid crosses Mendel's laws Chromosomal interpretation.

5. The evolution of organisms deduced from a paleotological study (the knowledge of scientific names of species is not required).

6. The main theories of evolution (limited to simple exposition).