CHAPTER B

Mathematics, the Natural Sciences and Technology for Students Specializing in the Sciences

Mathematics, the Natural Sciences and Technology for Students Specializing in the Sciences

The last few years have seen an increase in the number of students specializing in mathematics and science in high school. To a great extent, this can be attributed to university admissions requirements, changes in the structure of th matriculation examinations, and reforms in technological education. More needs to be done to improve the quality and size of this student population. The committee members view this group of students as a national resource. In a modern economy, this outstanding population, headed for the universities, leads the industrial and scientific development, which is the foundation of the modern economy. For this reason, the committee believes that the investment required to apply its findings - which might appear high in terms of the sums Israel traditionally budgets to education - is worthwhile, economically and otherwise. To reap the investment in education economically - which is not the only consideration - we must maximize the potential of the students by providing them with the best possible education in science and technology. We must work to constantly improve the quality of the scientific-technical education that this population receives and to strive to enlarge this population as far as possible.

The committee sees a clear hierarchy in the scientific disciplines. First is mathematics, the language of quantitative logic and the foundation of all quantitative thought. Every effort should be directed towards high school mathematics, so that each student can make the best of his/her abilities and talents. The basic subjects in the process of building scientific knowledge are physics, chemistry, and biology. These are the fundamental disciplines, the cornerstone for all human knowledge in science and technology. All courses in science and technology, therefore, should be based on the fundamental disciplines. All applied sciences are rooted in them. It follows that an educational program in science and mathematics cannot be constructed without a firm scientific foundation.

This framework necessitates several conclusions about the learning process in the school. Laying a mathematics-physics-chemistry foundation is a sine qua non for all studies in science and technology, especially at expanded levels. It follows, then, that a technological field cannot be studied before this foundation has been laid, and the foundation must be grounded in mathematics. For this reason, the committee maintains that the course structure in different fields should be unified, and that different subjects taught in different tracks should be combined. There is a definite need to unify the scientific discipline in the education system and to properly construct them according to the stated order. In particular, these measures will provide students in technological education with a realistic opportunity to learn the sciences, as recommended by the report on technological education reform. The scientification process in the technical education system began long ago, and today the possibility of opening scientific-technological classes is being raised. The technological education reform made a great step forward in this area. But this is not sufficient; we must strive to break down all the barriers. Every student in a technological track must be able to take science courses; every student in an academic track must be able to take technology courses. The education system should allow this freedom, predicated on instituting equivalent standards in instruction and matriculation examinations.

One of the weak points in high school science is laboratory work. We have not yet made full use of this field or made it an integral part of all areas of study, and it has not yet received proper recognition in the matriculation examinations. Part of the problem stems from a range of "practical difficulties." The committee gave this matter serious consideration and is of th opinion that we must now allocate resources and support to developing laboratories in high schools.

Recommendation B/1:

Expanded Mathematics Studies

The committee recommends that the education system make a genuine effort to increase the number and the scope of mathematics courses. The committee recommends encouraging students to elect more hours of mathematics (four and five units) - urging students to increase their mathematics load from three to four and from four to five units; advocating advanced programs (including university recognized mathematics studies) which go beyond the material on the matriculation examinations, to be run in conjunction with other bodies; promoting special programs which the Ministry of Education and Culture runs already today, designed to raise the number of students studying mathematics and to improve the quality of studies among youth from disadvantaged neighborhoods; initiating and supporting the development of additional and innovative programs in this field (like those which are integrated into projects to absorb immigrant teachers and scientists, supervisory programs, etc.); and permitting students to take their examinations early or late, allowing for flexibility as demanded.

With a view towards the overall picture, the committee devoted a great deal of time and energy to studying the possibility of enlarging and enhancing the educational framework for interested outstanding students. It found that increasing the scope of science studies in high school, as much as we might like the idea, is impossible without cutting back in other basic areas, a step which we cannot recommend. We must bear in mind that students with a scientific bent receive their last exposure to many fields in the social science and humanities in high school. The committee decided to make one exception to this rule, for mathematics, because mathematics is the foundation for all future development and because studying mathematics develops the groundwork for thinking and conceptualization in science and in other areas. The committee recommends taking all possible steps to increase the number of students who take more hours of mathematics and to expand the studies beyond the formal demands of the matriculation examinations. The committee recommends expanding existing special programs and introducing additional special programs to increase the number of students from disadvantaged neighborhoods who study mathematics.

Recommendation B/2:

Additional Electives in the Sciences

The committee recommends developing a number of experimental programs for additional electives in the sciences and technology. The committee also recommends that programs that have already passed the development and experimental stages be implemented in the high schools.

The committee would like to emphasize that these electives are not a substitute for the basic subjects in the sciences or for the clear hierarchy that the committee sees between basic and applied disciplines. The committee believes that science and technology, physics, chemistry and biology are the fundamentals -the basic subjects. Applied courses should be viewed as the next stage, which implements the basic principles. There must be an appropriate combination of basic and applied subjects.

The education system should now begin the wide-scale introduction of the following subjects:

Computer science

Prof. Amiram Yehodai chaired the committee which examined this subject. It recommended a computer science program with two possible variations, three or five units. This program should be tested, and at the same time, we should take steps to introduce it in the education system as a whole as an elective for junior high school students.

The committee recommends that curricula be developed for the following subjects and that they be tested in the schools.

A. Applied mathematics

Many countries give students the option of specializing in applied mathematics. This discipline is based on solving problems from various fields by applying numerical, mathematical, statistical and other methods. Applied mathematics is employed in many other fields. In Israel, a few groups are working in this area, and educational materials for the high school level are being written. We need to ascertain what is the desired scope of this subject and how applied mathematics should be integrated into mathematics and science courses.

B. A general technological course for students in academic and professional tracks

This course would introduce the student to all aspects of technology - planning, systems, energetics, information and materials. This course should be taken in addition to a basic science course of at least three units.

C. Environmental science and energy

People today are interested and involved in environmental science and energy issues. We should examine what elements of these subjects can be taught in the schools and how they can be applied. We are faced with cardinal issues in the national and global arena about the relationship between the development of society, industry and the economy and the ability of the natural environment to absorb the consequences of these changes. It is right that these subjects be part of the curriculum. This course should be taken in addition to a basic science course of at least three units.

D. Problem-solving and types of thinking

Many countries have instituted a program designed to improve the individual's problem-solving ability and to teach different types of thinking, such as critic thinking, creative thinking, innovative thinking, logical thinking, and so on. The possibility of including a similar program in the schools should be examined. This would also involve integrating problem-solving exercises and different types of thinking into courses in other subjects.

E. Earth science

This subject, which appears to be well-suited to a modular structure, includes elements of geology, geography, astronomy and astrophysics. Earth science has a lot in common with environmental science and energy. This course should be taken in addition to a basic science course of at least three units.

The committee recommends that all proposals for new curricula be thoroughly examined, both in the material they present (to what extent will it contribute to the future development of the student) and in their educational aspects (to what extent will the new course be an appropriate way to learn the subject, and is it a field of knowledge with a suitable structure, including features of scientific thinking). Close attention must be paid to the questions of how the new courses will be coordinated overall with the existing disciplines, what the new studies will consist of, and what combinations of the new electives will be permitted. After the experimental stage is completed, it will be necessary to develop educational materials and to train teachers.

Recommendation B/3:

Combined Science Studies

The committee recommends introducing a unified program for all areas of science and technology for all students, and proposes creating one system of supervision and guidance for these subject areas.

In the education system today, a number of scientific subjects are still taught separately in different educational frameworks, using different curricula, and under separate supervision. The committee believes that this system should be ended, and that the sciences that are taught in different frameworks should be unified. In everything related to mathematics, science and technology, the curricula used in a certain subject should be unified so that all the students will use a standard program, which will be under the same supervisory system. The committee proposes that certain scientific courses that are given only in the technological and agricultural tracks be restructured as optional subjects f students in these two tracks. From our examination of the educational materials, we believe that these will not be major differences quantitatively, and they can be made up with electives.

We should unify all tracks of biology, the agricultural and technological tracks of chemistry (food, textiles, laboratory work and photography) and electricity and physics. This measure will lead to a more rational book publishing system, more efficient supervision (which will free up resources for guidance), and unified standards, making it easier to design continuing programs and for graduates to receive recognition from different places.

We must bear in mind that if these divisions could be justified in the past in light of the specific-technical approach, which was characteristic mainly of the training-related disciplines, today, all these fields clearly demand that the individual have a firm general science background. Therefore, the divisions should end, and the student should be given a general schooling in the sciences. All specializations will come later, but they need to be built on a solid foundation of basic science study. Modern agriculture is largely dependent on modern life sciences, and separating biology from agriculture does not allow the students who want to specialize in agriculture to receive the proper educational groundwork.

Courses in electricity for electricians also fall short. This is mainly a funct of not providing the background in mathematics and physics which are essential for developing technological thinking. The student of technology must receive the full requisite background in physics, with emphasis on the theory of electricity as an elective.

The committee's recommendations take into account contemporary developments: all technical and agricultural endeavors are increasingly based on scientific processes, and workers at all levels must receive a firm foundation in the sciences during high school as a prerequisite for proper future development at all professional levels. Therefore, the distinction between different types of scientific education is no longer relevant. We need to create a proper unified scientific education system, which will serve as the foundation for the student when s/he enters a post secondary program of specialization. Without this base, the student will not be able to understand and absorb new developments in his/her field.

The committee is of the opinion that this unification might free up educational resources in different forms and at various levels, which can then be used to advance this subject in general.

Recommendation B/4:

Science in Technological Education

As a follow-up to measures taken by the technical education system in the framework of educational reform, it is proposed that science courses in the technical education system be significantly expanded, giving the students in different tracks complete flexibility in choosing courses - science courses for students in technological tracks, and technology courses for students in academic tracks.

The committee recommends that all high school students be given greater freedom in choosing science courses and that constraints in choosing subjects in all tracks be lifted.

There are still certain places in the education system where students in technological tracks do not receive the required number of relevant science courses, because of the course load required for technological studies and the structure of the students' schedules. It is clear today that high school technology courses are not meant to train professionals for the job market. Instead, this is a preparatory framework, similar to the academic track, designed to prepare the graduates for further training and study. Graduates of the technological tracks complete their training at institutes of higher educati colleges, post-secondary programs in technical and engineering skills, and other directed training frameworks in industry, the army or elsewhere. Therefore, programs in these tracks should be of maximal use to the student and allow him/her as much flexibility as possible in the future. Here, flexibility refers primarily (but not only) to the professional aspect. The technological graduate needs this flexibility to deal with interdisciplinary innovations in his/her fie to have a general scientific competence, and to have the possibility for professional mobility.

More than once, the committee heard about the difficulties faced by graduates of the technological education system in the past in adapting to new technologies, because of their lack of knowledge of the basic sciences, mainly physics and chemistry. The problem was not a result of the quality of the courses they attended, but of what they had missed. The previously well- defined distinctions between technological disciplines have been blurred, and today a broad basic education in the sciences is a prerequisite for understanding new technologies. A similar phenomenon, at a different level, is happening today all over the world in training engineers. These findings tally with the recommendations of committees in other countries, namely that a solid education in the sciences is more important than professional specialization, even for a person who works on a modern assembly line. Today the leaders of industry place more importance on the employee's background in science than on his/her technological specialization. Industry-owners explain that the employee will learn the specifics of the technology at work, and the specifics will change several times during a career. These trends are apparent in the acceptance requirements for engineering schools and in the fact that the technological tracks of some schools in Israel now offer academic programs with a definite scientific orientation.

For these reasons, and in light of recommendations offered by people in industry, the committee is highly supportive of the measures taken by the Science and Technology Department in the last two years, in the framework of the technological education reform. These changes reflect the spirit and needs of the time. The committee believes that the reform was a step in the right direction. We should carry on by creating a unified framework for all scientific and technological education, both in terms of the scope of the course and the units for the matriculation examinations. This would enable students to freely choose to take different subjects. Students in the technological trac should be encouraged to take basic sciences, like physics and chemistry, in addition to their technological courses; students in the academic tracks should be able to study technology. This should be accomplished without giving the students an overly heavy course load. Some schools already have an arrangement like this one, and offer a program that includes five units of mathematics, five units of physics, and five units of electronics. The committee would like to draw attention to the fact that in the past, students in technological tracks hardly took chemistry, and certainly not to the extent that this subject should be studied today. This situation must be changed.

For example, today some technological schools have a "scientific" track with a similar course of study. This track responds to the demands of the students, principally those at higher levels, who prefer these studies. This trend should be supported: all students in technological tracks should be allowed to make this type of choice, while carrying an appropriate course load and being offered a suitable number of courses in different subjects. The committee envisions only one limitation on the student's freedom of choice - the need to correctly build the student's overall knowledge, beginning with the mathematical base, then moving to the basic subjects, and finally to applied topics.

Because of the special framework of technological education, however, in many schools the majority of students in the academic track are unable to study a technological subject even if they so desire, and often, this is true ev when the course is given in the same building. By standardizing the structure of the disciplines and the possibilities for choice, we can enable all students a wider selection of subjects and can move closer to our goal - raising the scientific ability of students in the technological track, and increasing the number of students from the academic track who take technological subjects. In anticipation of this move, we should reexamine the curricula of the technological disciplines, to tailor the educational materials to students from academic tracks who are interested in studying a certain technological subject, even when it will not provide the required training to receive official professional certification to actually work in the field. The committee views its recommendations in light of the future when the education system will have a unified scientific-technological program.

The committee is aware that implementing this proposal will pose difficulties for the traditional structure of the disciplines in technological education. Nonetheless, the committee members are firm in their belief that the technological-scientific developments that have already taken place, as well as those expected in the near future, necessitate this new structure, which enhances the basic scientific education for students in technological tracks and opens technological courses to students in academic tracks. It seems to us that in the not-too-distant future, we will be speaking more and more about the scientific-technological education system and no longer about the technological education system as a separate entity. This change is reminiscent of when the education system moved from professional education to technological education, a concept that, at the time, reflected the transition to more sophisticated subj matter. Today we are talking about a new stage in this process, when technological and scientific education become one unit.

Recommendation B/5:

Computers for Teaching Mathematics, Science and Technology

The committee recommends expanding the use of computers for teaching mathematics, science and technology in high schools.

Computers should be used extensively in teaching the sciences, both as an educational tool in presenting the subject matter of scientific disciplines, and as a learning aid. The computer offers a whole range of possibilities, including graphics options, work with information banks and data bases, communications applications, and functioning as a laboratory instrument.

Many experiments in the natural and social sciences cannot be replicated in the schools. In the classroom, it is impossible to change gravitational force. The student - and even the teacher - cannot jump on the moon. They are also unable to eliminate friction or resistance. Experiments in all these fields, however, can be simulated on the computer screen. While we cannot install nuclear reactors or radiation sources in the classroom, we can simulate the way they work. This also holds true for experiments in ecology, economics and many other fields in the social and natural sciences. Equipped with appropriate courseware, the student can alter the physical, ecological or economic conditions of a system, study the consequences of the changes, and test his/her deductions. The computer thus becomes a engrossing laboratory which lends a new dimension to the learning process.

In the laboratory, the computer helps in measuring, collecting deciphering, processing and displaying data, as well as functioning as a simulation instrument. Computer applications can be learning aids in the process of scientific thinking and analysis; the advanced environments - including video functions - can be employed for experiential and educational enrichment. Up-to-date methods and tools for using information banks should be utilized in schools by both teachers and students. Computers with communications features can be used to gather and decipher information. Computerized tools which represent two and three-dimensional environments should be employed in different areas. In other words, computerized instruments that can be used to analyze and display data, draw conclusions and solve problems should be included in the program of developing specialized thinking in different subject areas. All of these require a joint effort of computer specialists and curriculum writers.

The education system is responsible for several tasks - defining applications; recommending computer hardware, software and peripherals; mapping needs and existing systems; characterizing needs in mathematics, science and technology; and trying and approving software and courseware.

The committee recommends:

A. Software and courseware development:

The development of software geared to the curriculum of different disciplines should be promoted. Resources should be allocated for this purpose, and procedures for conducting quality control and approving software for school use should be established.

B. Purchase of software and courseware:

Software and courseware should be purchased in a manner similar to that used for equipment.

C. Teacher training:

The subject of computer applications in teaching technology and the sciences should be included as part of the process leading to certification in teaching the sciences.

D. In-service training for teachers:

A comprehensive series of in-service training workshops should be designed for high school teachers. This program will have two stages: computer literacy and computer applications in teaching.

E. Advanced experiments

The introduction of computer applications experiments, using different methods and based on state-of-the-art technologies, should be encouraged. This includes experiments in advanced environments, information banks, and active learning based on communications systems and information processing.

F. Matriculation examinations

The process of characterizing the different subjects - in order that within five years, computerized experimentation can be included on the matriculation examinations in mathematics, science and technology - should begin. There are already some examinations that make use of the computerized environment.

Recommendation B/6:

Laboratories in the High School

The committee recommends a new approach to the subject of laboratories in teaching science at the high school level. Laboratory work should become an integral component of science studies.

We need to reexamine the content and objectives of laboratory work in the process of studying the sciences. Despite important work in this field, especially by the teams who developed existing curricula, the area of laboratory applications in the learning and testing process in high school science remains inadequate. The laboratory still does not play an integral role in the development of the student's scientific knowledge in most areas; the scope and content of laboratory work continue to be insufficient; and the laboratory is not closely related to the course material. In some schools, science instruction is still largely taught with a blackboard and a piece of chalk. In the last few years, new possibilities have opened up in the field of integrating the computer as a laboratory instrument. They include simulation- based activities using the computer to change reality, and experiments in which the computer is used to collect information, take advanced measurements, and display and process data (see Recommendation B/5).

The committee proposes that the education system begin a project of developing the experimental laboratory framework for teaching scientific disciplines at the high school level, in an effort to revise the curricula, the goals and the way the laboratories operate. We must precisely define our objectives and plan laboratory projects, while integrating laboratories completely into the learning process and the matriculation examinations. The unique goals of laboratory experimentation should be emphasized, beyond verification and knowledge of the material. This means experimental skills, an inquisitive approach, and the ability to relate what happens in reality to theory.

Apart from the conceptual aspect of the project, attention must be paid to the physical and operational conditions of the school. It is important to emphasize that when the new design for science laboratories is published, the schools need to have appropriate conditions in keeping with this plan, namely laboratories, suitable equipment, bibliographical aids and structural accessibil including a technical support staff. The committee feels that these require the presence of a laboratory technician responsible for preparing the laboratory for the classes and for carrying out ongoing maintenance work.

The committee suggests that each institution make appropriate laboratory arrangements, according to the subject being taught. Every subject coordinator will determine the laboratory program for each class in the various subjects.

The committee recommends updating the bibliographical aids and laboratory programs for each discipline; the subject of laboratory work should be included in a significant and meaningful way in the matriculation examinations of different disciplines.

Recommendation B/7:

Science-Oriented Youth

The committee recommends expanding the Science-Oriented Youth program -increasing the number of participants, augmenting the activities and dealing with a greater variety of topics. Particular attention should be given to reaching the population of development towns and disadvantaged neighborhoods.

The Science-Oriented Youth program acquaints large groups of the population with science, and develops their scientific knowledge and interest in the sciences. The program is based on exposing students to researchers working in institutes of higher education in the natural sciences, mathematics, computer and engineering. Today about 10,000 young people participate in extracurricular classes and summer camps.

In the committee's view, the Science-Oriented Youth program should be expanded by taking the following steps:

(A) Adding activities in cooperation with industrial enterprises, industrial laboratories, health care institutes, and so on, in addition to existing programs. This would enable extracurricular classes to be held in industrial and other frameworks (apart from the activities in academic settings), in order to expose the students to what is happening today in production, applied research, health care, etc. It is important to closely monitor the quality and level of the activities; a planning and supervisory mechanism should be established for this purpose.

(B) Aiming for a wider geographical distribution of activities. The universities should conduct programs outside their campuses, to reach people in more remote locations.

(C) Opening extracurricular classes in science and technology in schools, youth centers and community centers, directed by the staff of the Science-Oriented Youth program. These classes must be given by experts in their fields, who will come to the school or center. The level of these activities must be high, to give the participants proper exposure to the scientific-technological environment. This is most important in development towns and disadvantaged neighborhoods, and activities in these places must be emphasized.

(D) Establishing a financial aid program to enable students from the lower socioeconomic sectors of the population to participate in the Science- Oriented Youth program. Today the program receives 20% of its funding from the Ministry of Education and Culture, with the rest financed by the parents. The committee recommends that parents in economic distress be charged according to a sliding scale, to enable their children to participate in the activities.

(E) Producing special educational materials, mainly translations of appropriate literature, tapes, etc.

Recommendation B/8:

Schools with an Emphasis on Science and Technology

The committee recommends that a group of schools be established as "schools with an emphasis on science and technology."

This recommendation refers to high schools that specialize in teaching advanced-level mathematics and/or sciences and/or technological disciplines. The objective is to have a group of leading schools that will place an emphasis on science and technology, which will provide advanced solutions for the population of students wishing to specialize in these areas. The special school will need to have a high-quality facility, teaching staff, and curricula. In addition to providing a high level of instruction in the general disciplines, a school in this group will offer advanced programs in its area of specialization, and will expose its students to experiments and studies which go beyond the customary requirements. These institutions will work in cooperation with the universities and industry and will excel in their field. They will exercise freedom of choice in emphasizing a number of subjects in their areas of expertise, but will be expected to offer a logical constellation of subjects whi will encompass the body of knowledge in science and technology. It is important to stress that there will not be a division between the sciences and technology, but rather, the sciences will be related to the relevant technologie

With the approval of the supervisor, these schools will also be authorized to run special programs. The achievements of at least some of their graduates will surpass the regular requirements, and the schools will offer different programs in their areas of expertise, including student projects and senior theses. Suitable students will study at an accelerated pace and complete their high school requirements early, in order to take part in university programs before graduation. The schools will also offer special frameworks to advance students from disadvantaged areas.

These schools will fulfill conditions such as the following:

(A) A comprehensive and general approach to education, with properly constructed instructional disciplines.

(B) An experienced instructional staff, with teachers who hold higher university degrees and regularly participate in in-service training workshops in their subject areas.

(C) Advanced scientific administration, headed by a senior staff member of the school - the principal or assistant principal.

(D) The use of appropriate curricula, and matriculation examination scores that we would expect to see from students in an institution like this.

(E) Complete compliance with providing the required hours in subjects that are not in the school's area of expertise, and providing extra hours in the emphasized disciplines.

(F) A suitable instructional infrastructure, including laboratories, equipment and support staff.

(G) Proper use - according to subject and needs - of the activities offered by regional centers outside the schools, which can provide high-level instruction, up-to-date equipment and advanced activities (see Recommendation B/9).

(H) Cooperation with academic and industrial enterprises.

(I) Accepting students from a defined geographical area and giving special attention, including advancement programs, to students from lower socioeconomic backgrounds.

(J) Demonstrating long-term success in the achievements of graduates, including graduates who excel.

(K) Success in advancing weaker sectors of the population.

This project will receive a certain budget allocation to assist the schools in question, but this does not mean that the development of these institutions will be completely financed. Most of the capital for infrastructure and operation must come from outside sources, and the institutions will be responsible for finding this funding. This also includes existing institutions which will take special measures to join this project.

Recommendation B/9:

Regional Centers for Science and Technology

The committee recommends that advanced instructional sites in science, technology and computers be declared as regional centers for teaching science and technology, on an experimental basis.

In the past few years, science and technology centers have operated in a number of places: Kiryat Shmona, Tel Aviv, central city laboratories, science laboratories at the Hebrew University, and support centers for technological studies, such as the center in Beersheva. All of these are variations on the same theme: a concentration of advanced instruments, generally in conjunction with an excellent instructional staff -- a combination that is beyond the reach of most schools. In some cases, these centers offer an addition or enrichment to science studies at the school; in others, the centers are a substitute for in school instruction. In some centers, the class teacher conducts the lesson, and other centers provide an expert from their staff. A number of centers employ outside experts to provide guidance and help students with their senior theses.

Science and technology centers can provide instructional services to students specializing in the sciences, offer advanced laboratory services, and serve as a place for developing and trying out curricula, senior theses, and laboratory experiments.

The committee recommends that these centers furnish instructional and laboratory services to school groups in their regions, as needed. This refers to regions where it is difficult to provide appropriate conditions for teaching mathematics, science, technology and computers (either because of the size of the schools or for other reasons) and places which decided to enable the students to progress beyond the regular school program. The advantages offered by the centers are in creating the proper scientific-technological atmosphere, providing good equipment which is properly maintained with the help of a technical staff, and having an excellent technical and professional educational team. There is also the possibility of forging a relationship with the universities, as part of the center's activities.

These centers can operate in several ways, as circumstances, needs and conditions demand: to be a place where courses and laboratory work are conducted; to furnish alternate instruction in mathematics, science, technology and computers; or to provide additional enrichment for the educational environment in carrying out research and projects. In addition to exposing students to a well-equipped laboratory in a suitable environment, the center saves money and concentrates the capital invested in purchasing and maintaining laboratory equipment.

The committee recommends that several versions of this experiment be developed, to study efficiency and instructional benefits. The activities will monitored, and at the end of the experiment it will be decided which of the models should be promoted and put into wide use.

Thanks to the teleprocessing conditions existing today, it is possible that the center will use a computer network linking the schools to transmit information about experiments and other matters both to and between the schools. A science and technology center can also provide the schools with educational materials and information about different subjects. All of these are in additio to the basic instructional and laboratory services provided. These centers can also be involved in other work, such as organizing day visits of junior high school classes; advising students on their senior theses; providing in-service training and demonstrations for teachers; sending teachers from the centers for special days at the schools; and lending advanced equipment and instructional materials.

Recommendation B/10:

Journals for Science and Technology Teachers

The committee recommends establishing journals for mathematics, science and technology teachers.

Although there has already been some progress in this field, the teachers' needs have not yet been met. The committee suggests publishing a series of professional journals designed for people who teach mathematics, science, technology and computers.

The journals will provide a platform for teachers and experts in different subject areas. They will present material relevant to teaching - ideas for lessons, different experiments, and information about what is happening in different countries in mathematics, science and technology instruction. The journals will be part of "Tomorrow 98," serving as a means for the project staff to communicate with teachers.

Teachers and groups responsible for the development of curricula and teaching materials in science and technology, headed by the Center for Science Instruction, will be active participants in producing the teachers' journals.

Recommendation B/11:

Flexible Graduation

The committee recommends having a flexible date for finishing mathematics, science and technology studies. The committee also proposes establishing simple and convenient arrangements that will enable the student to sit for the matriculation examinations before or after the date set for the class.

This matter is relevant for gifted students, who are ahead of their classmates, and for weaker students, who need additional time to meet the matriculation examination requirements in mathematics, science and technology. To ensure that this recommendation be implemented in an orderly, regular and simple manner, the Ministry of Education should establish appropriate arrangements, design a reporting system for schools, and determine rules and procedures. This should be coordinated with the military authorities. It is clear that holding early examinations for an individual or a group will not be grounds for additional funding. The arrangement made with the social services budget and the budget for programs in this field will apply to funding for extended studies.

The students who graduate early will use the time they gain to continue their education, in conjunction with academic institutions. Similarly, the extension courses can include additional specializations in professional fields. Both of these arrangements should be encouraged.

In general, the committee advocates granting schools flexibility in allocating the means earmarked for teaching science and technology, so that they can best meet the students' needs.