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ABSTRACT

This document contains four papers presented at a conference on technological literacy and technology education in Taiwan. The papers are the following: "Technological Literacy: An Engineering Perspective" (Ming H. Land); "Implementation of Technology Education in Japan--(Revised Edition)" (Shoji Murata); "Evaluation of Technology Education: The Case of Japan" (Shoji Murata); and "A Study of Introduction of 'Foundation of Information' and Individuality Based Instructions" (Shoji Murata and Masao Murata). All the papers contain reference lists. The first three of the papers are translated into Chinese and are included with the English version in the proceedings. (KC)

技學素養與技學教育研討會
論 文 集

Proceedings of
Workshop on Technological Literacy
and Technology Education

行政院國家科學委員會科學教育發展處　補助
國立台灣師範大學工業科技教育系　編印

中華民國八十五年三月

Funded by: National Science Council, Republic of China
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序

近幾年來，國內工藝/科技教育(industrial arts / technology education)有不少的開展與變革。例如：在行政院國科會科教處的規劃、推動與補助下，已完成許多有價值的技學素養(technological literacy)教育專題研究。而國、高中的現行工藝科課程標準也已經完成修訂，並將分別自八十六及八十七學年度起實施。在新的課程標準中，工藝將改名為生活科技，且以培養和提升學生的科技素養（即技學素養）為目的。

這些專題研究和課程標準的理論與實務應該有持續的研討，才能擴大效果和精益求精。因此，本系在國科會科教處的經費補助下，於民國八十五年三月四、五兩日在台灣師大工教大樓舉辦了「技學素養與技學教育研討會」。會中特別請美國北卡羅萊納州立阿帕拉契大學藍敏慧院長，及日本國立金澤大學村田昭治教授作專題演講。本論文集所彙編的文章即是兩位主講人的論文及其中譯。非常感謝兩位主講人及本系黃能堂教授和游光昭教授兩位譯稿人的貢獻，以及感謝本系上官百祥老師和林淑芬小姐彙編本論文集的辛勞。

其次，本次研討會之得以順利舉辦，首先要感謝國科會科教處郭重吉處長、郭允文研究員、和王台徽科長的大力支持，本系全體老師、同仁參與籌劃，還有李大偉院長、余鑑教授和方榮爵校長的幫忙主持，呂清夫教授的協助口譯。其次要一併感謝下列工作小組同仁、同學的辛勞：（1）總幹事：黃能堂，（2）業務組：賴志樫、林政宏、張美燕、魏小芳、顏榮泉，（3）議事組：上官百祥、陳雅珮、范道明、黃珮玲、林韶姿、林素惠、趙雅玲、劉桂玫，（4）接待組：朱益賢、王應文、石德光等，和（5）總務組：林弘昌、林麗萍、白景文、謝進生。

台灣師大工業科技教育系教授兼系主任

李 隆 盛 謹識

八十五年三月

目　　錄

TECHNOLOGICAL LITERACY: AN ENGINEERING PERSPECTIVE

Workshop on Technological Literacy and Technology Education

National Taiwan Normal University, Taipei, Taiwan, R.O.C.
March 4-5, 1996

Presenter: Dr. Ming H. Land
Professor of Technology and Dean
College of Fine and Applied Arts
Appalachian State University, Boone, NC U.S.A.

The world is being rapidly transformed by science and technology in ways that have profound significance for the economic well-being in a democratic society. One major impact is that work will require much scientific and technological competence and a great deal of flexibility and adaptability to an evolving body of knowledge and new opportunities requiring modified skills. Successful participation in a rapidly changing world economy will require that we have a more skillful and adaptable citizenry and workforce than ever before. This is the vision of a world-wide educational reform that recognizes scientific and technological literacy as the cornerstone where all individuals can participate fully as citizens and as productive workers. The challenge for technological education is to develop a vision and framework of what constitutes technological literacy and design and build curriculum that enhances technological literacy.

Technology Education and Technological Literacy

Early Concept of Technological Literacy. The concept of technological literacy, although relatively new in the history of education, was expressed by John Dewey (1916) in his book titled Democracy and Education:

It is pertinent to note that in the history of the race the sciences grew gradually out from useful social occupations. Physics developed slowly out of the use of tools and machines; the important branch of physics known as mechanics testifies in its name to its original associations. The lever, wheel, inclined planes, etc., were among the first great intellectual discoveries of mankind, and they are none the less intellectual because they occurred in the course of seeking for means of accomplishing practical ends.

Dewey continued to advocate education for scientific and technological literacy based on industrial occupations (technology) when he stated:

Industry has ceased to be essentially an empirical, rule-of thumb procedure, handed down by custom. Its technique is now technological: that is to say, based upon machinery resulting from discoveries in mathematics, physics, chemistry, etc. The economic revolution has stimulated science by setting problems for solution, by producing greater intellectual respect for mechanical appliances. And industry received back payment from science with compound interest. As a consequence, industrial occupations have infinitely greater intellectual content and infinitely larger cultural possibilities than they used to possess. The demand for such education as will acquaint workers with the scientific and social bases as bearings of their pursuits become imperative, since those who are without it inevitably sink to the role of appendages to the machines they operate.

He concluded by stating that:

Skill and information about materials, tools, and laws of energy are acquired while activities are carried on for their own sake. The fact that they are socially representative gives a quality to the skill and knowledge gained which makes them transferable to out-of-school situations.

Students of history of education all know that Dewey was strongly opposed to state and federal legislation which would establish separate systems of vocational schools alongside the general education. Instead, he proposed a new kind of industrial education as part of general education reform whose aim would be to cultivate "industrial intelligence," a popular term of the time that we call it today technological literacy. Dewey's (1917) definition of "industrial intelligence" was: a knowledge of the conditions and processes of present manufacturing, transportation and commerce so that the individual may be able to make his own choices and his own adjustments, and be master, so far as in him lies, of his own fate.

AIAA and ITEA. From the perspective of technology education profession, the first real impetus to the introduction of technology education based on technological literacy came in 1947 when Dr. William E. Warner and a group of his graduate students at The Ohio State University proposed "A Curriculum to Reflect Technology," at the American Industrial Arts Association annual conference, which introduced five areas of technology--communications, construction, power, transportation, and manufacturing--for the study of industrial arts that would replace the vocational areas of manual and industrial arts education such as woodworking, metalworking, drafting, and printing, etc. Much of the curriculum efforts in industrial arts and technology education that followed until now have been strongly influenced by this curriculum concept. A common technology education program at the high school, according to Gilberti (1994), still includes these five areas and numerous courses:

Common Technology Education Courses at the High School

Communication

Introduction to Communication
Design/Drafting
Photography
Graphic Arts
Telecommunication

Manufacturing

Introduction to Manufacturing
Materials Processing
Computer-Aided Manufacturing
Production Technology

Transportation

Introduction to Transportation
Aviation Technology
Atmospheric Transportation
Marine Transportation
space Transportation
Terrestrial Transportation

Construction

Introduction to Construction
Materials Processing
Architectural Drawing
Commercial/Residential Construction

Energy and Power

Introduction to Energy and Power
Alternative Energy Sources
Electronic Control Technology
Electronics
Principles of Technology Robotics

Capstone Courses

Research and Development
Applications of Technology
Invention and Innovation

In 1950, under Dr. Warner's direction, Delmar Olson wrote his doctoral dissertation titled Technology and Industrial Arts that recommended the study of technology for industrial arts. His book, Industrial Arts and Technology, published in 1963, stressed the challenge of technology as a source for students' discovery and development of aptitudes and applications in the field of industrial arts education. One year later, Paul DeVore (1964) wrote an influential monograph titled Technology: An Intellectual

Discipline. This document laid the foundation for technology as the original framework for curriculum development that is known today as technology education.

The Jackson's Mill Industrial Arts Curriculum Theory (Snyder and Hales, 1981) is considered by many technology education professionals as a very significant curriculum document of the 1980s. The Jackson's Mill concept was further modified as Jackson's Mill II which combines manufacturing and construction into production technology and adds bio-related technology to technology education curriculum.

It is the International Technology Education Association (ITEA) that has brought the concept of technological literacy to the forefront of the technology education profession in the 1990s. ITEA's professional improvement plan for 1990 to 1995 states its mission as follows:

The mission of the ITEA is to advance technological literacy. Consistent with this mission, ITEA challenges its members to:

1. Provide a philosophical foundation for the study of technology that emphasizes technological literacy.

2. Provide teaching and learning systems for developing technological literacy.

3. Foster research and advance technological literacy.

Definition of Technological Literacy. The 40th yearbook of the Council for Technology Education was devoted to the topic of technological literacy, It represents the most comprehensive study on this topic to date. Technology literacy is defined as follows:

> Technological literacy is a multi-dimensional term necessarily includes the ability to use technology (practical dimension), the ability to understand the issues raised by or use of technology (civic dimension), and the appreciation for the significance of technology (cultural dimension). (Dyrenfurth, 1991)

David J. Pucel, a professor of vocational and technical education at the University of Minnesota, has been a consistent advocate for technology literacy. In 1989, he wrote an article in the Journal of Technology and Society that proposes technological literacy as a goal and role for industrial arts education. His latest article (1995) in The Technology Teacher defines technological literacy as:

> The possession of understandings of technological evolution and innovation, and the ability to apply tools, equipment, ideas, processes and materials to the satisfactory solution of human needs.

This definition is based upon the assumption that technologically literate people have two primary characteristics: (1) they understand the technological method; and (2) they have developed basic "common sense" level knowledge of technology through experiences with tools, equipment, ideas, processes and materials.

Echoing the call for technological literacy by ITEA, Dr. Lung-Sheng Lee (1991) of National Taiwan Normal University proposed a name change for industrial arts in Taiwan's educational system to technology education in a May 1, 1991 article of the Central Daily News. He stated that the main purpose of industrial arts education is to enhance technological literacy of students. He described the human environment that has been technological. When we are looking at a home or an office or through a window opening onto landscaping, we are looking at human constructs, tailored by technology. Engineering and technology have in large measure created modern history. Technology education offers a solid grounding that would go far in equipping students for life in the technological world.

Technology for All Americans. Spearheaded by ITEA, Technology for All Americans project, with the main theme of "Technological Literacy: Expanded Capability for a Changing World" and under the direction of Dr. William E. Dugger of Virginia Tech University, was started in 1994. Funded by the National Science Foundation (NSF) and the NASA, it is the largest research project ever funded for the study of technology education. Phase I of the project is to develop a rationale and structure for technological studies and build national consensus on the issues. Phase II, which is to begin in 1996, will develop standards for technology education programs in grades K through 12 along with standards for teacher education. When completed, this project will bring latest research and innovative ideas to the development of a vital vision concerning how technology education interfaces with science, mathematics, engineering, and other discipline.

Science, Engineering and Technological Literacy

Engineering Initiative. Technological literacy has also been the focus of the science and engineering disciplines. As far back as 31 years ago, a secondary-school curriculum called The Man-Made World: Engineering Concepts Curriculum Project (ECCP), under the direction of Polytechnic Institute of Brooklyn, advocated technological literacy as a major goal of education for all people:

> While ECCP has prepared specific educational objectives for teachers to evaluate their effectiveness, the true goal of the course is to start toward technological literacy.

The writers of the ECCP project warned three decades ago that "the problems we face as a nation are monumental. We not only need to understand technology, we must also anticipate its side effects. Change today is so rapid and the visible effects are often so delayed that the wrong decision can lead to major problems before the effects can be reversed. The ECCP project recommended that precollege education equip students:

1. To use technology to improve the quality of many personal and professional technology-based decisions.

2. to participate intelligently as informed citizens in the transition from an industrialized society to a post-industrialized service and information age.

3. To be more active in shaping public policy, which often involves the use of sophisticated technology.

In order to achieve the goal of enhancing technology literacy, two books were produced by the ECCP project to serve as basis for instruction at the high school level. The first book, Man and His Technology, covers primarily the fundamental concepts of technology of the 1970s in the following units: Technology to Serve Man, Decision Making, Optimization, Modeling, Systems, Patterns of Change, Feedback, Stability, Machines and Systems. The second book, Man and His Technology: Problems and Issues, includes the following nine units: Systems and Decisions, Population, Delivery of Health

Services, Emergencies, Decisions, Energy Crisis, and Noise Environment.

Science and Technological Literacy. The National Science Board Commission on Precollege Education in Mathematics, Science and Technology (1983) criticized schools in the U.S. for not providing adequate technology education in schools and urged American education to develop a comprehensive, contemporary technology education in the elementary and secondary schools in two approaches: (1) a specially one-year course treating technological concepts, or (2) integration of technology through other instructional topics from kindergarten to high schools. The technology education program proposed by the Commission was greatly influenced by the ECCP project as reflected in the following technological skills recommended by the Commission:

1. Formulating and solving problems and identifying alternative solutions to problems.

2. Making connections between theory and practice, building and testing models.

3. Examining trade-offs and risk analysis, synthesizing and designing.

4. Using the concepts of feedback and stability.

The author (Land, 1984), in an article in The Technology Teacher, echoed the Commission's call and urged the technology education profession and ITEA to assume greater leadership and responsibilities for providing technology education for all American Schools. The author warned that "if our profession does not take the leadership role and accept this challenge, other fields (e.g., science, mathematics, and junior engineering program) will take over this important mission.

In 1985, the year in which Comet Halley was in the earth's neighborhood, the American Association for the Advancement of Science (AAAS) undertook a comprehensive, long-term initiative to transform science, mathematics and technology education for the 21st century--Project 2061. Why 2061? The period of the comet, about 76 years, closely approximates the average human lifespan in developed nations. Thus, we can expect about half of the people born in 1985 to live to see the next appearance of Comet Halley in 2061. Project 2061 is predicated on the belief that the quality of life in 2061 will depend above all on the education received by this generation of children and the next. Project 2061 believes that those young people need to leave school with a solid education in science, mathematics, and technology--one that will enable them to participate intelligently in science and to become responsible and productive members of society. In addition, education must prepare them for an uncertain future and it must include understandings and habits of mind that can serve as tools for thinking throughout life.

To achieve the goal of science, mathematics and technology education, Project 2061 unfolded in two stages. Phase I, addressed what future generations should know about science, mathematics and technology in a 1990 publication titled Science for All American. Phase II transformed these learning goals into new curriculum concepts in a 1993 publication titled Benchmarks for Science Literacy. Science Literacy, which includes technological literacy, is defined as follows:

> Science Literacy. A literate person is an educated person, one having certain knowledge or competencies. But of course the rules keep changing with regard to precisely which knowledge and competencies define literacy....In today's world, adult literacy has come to include knowledge and competencies associated with science, mathematics, and technology. Project 2061 has undertaken to identify the knowledge and habits of mind that people need if they are to live interesting, responsible, and productive lives in a culture in which science, mathematics, and technology are central--that is, to describe what constitutes the substance of science literacy....Science literacy enhances the ability of a person to observe events perceptively, reflect on them thoughtfully, and comprehend explanations offered for them. In addition, those internal perceptions and reflections can provide the person with a basis for making decisions and taking action.

Dr. Paul E. Gray (1988), a distinguished scientist and engineer and former president of the Massachusetts Institute of Technology, has also been a strong advocate for scientific literacy. He warned that America's ignorance of science and technology poses a threat not only to the economic vitality but also to the democratic process. He urged schools and colleges to "provide new programs with a broad and comprehensive knowledge of both the liberal arts and science and technology."

In 1988, ITEA joined with various professional and academic groups such as the NSF and AAAS to form the National Association for Science, Technology and Society (NASTS). Since then, NASTS has sponsored its annual conference, known as the Technology Literacy Conference. The conference offers participants the chance to meet with others from around the U.S. and the world who are concerned with the technology and science issues facing society.

In recent years, the NSF has funded two research projects that integrate science, mathematics, and technology at the middle school level. One of these is the Illinois State University project. The other is at Virginia Tech University, titled Technology/Science/ Mathematics Integration project. It has developed over 40 activities for the technology, science and mathematics teachers to integrate their subjects at grades 6-8.

Principles of Technology (PT) is a course for vocational students interested in technical careers and other secondary students wishing to further their understanding of the physical principles underlying modern technology. The development of the PT course is a cooperative activity of a consortium of 42 state vocational education agencies in the U.S. and Alberta/ACCESS network in Canada in association with the nonprofit American-Canadian Agency for Instructional Technology (AIT) based in Bloomington, Indiana and the Center for Occupational Research Development (CORD) in Waco, Texas. PT includes 14 units of instruction, with each unit dealing with one principle as it applied in the four technological systems--mechanical, electrical, fluid, and thermal--that make up both simple and complex technological devices and equipment. The units are generally presented over two years and in the following sequence:

First-Year Units: Force, Work, Rate, Resistance, Energy, Power, and Force Transformers

Second-Year Units: Momentum, Waves and Vibrations, Energy Converters, Transducers, Radiation, Optical Systems, Time Constants

PT has it origin in vocational education. It is, therefore, not a course on implementing technology education. However, as McCade (1991) put it, "the more one learns about PT, the more strongly held is the conclusion that we in technology education could learn much from it." McCade further stated:

> PT is better at developing a basis for continuing learning about technology than many courses identified as technology education. PT has an organizational structure which helps students develop an understanding of universal concepts of technology. Too often, even courses labeled technology education impart skills which quickly become obsolete. These universal concepts of technology will not become obsolete and thus provide a foundation for life learning in technological literacy.

Engineering-Based Technology Education. An exemplary technology education program in the U.S. that complements mathematics and science and integrates engineering into its content is the technology education program in the State of New York. In March 1984, New York State Board of Regents published the Regents Action Plan, which requires that every student in New York State complete one year of technology education by the end of grade eight. Schools in New York State typically offer a half year of the Introduction to Technology program in seventh grade and a half year in eighth grade. In seventh grade, students examine the historical evolution of technology with emphasis on the major branches of technology--physical, biological, information and communication. Students study the systems and subsystems of technology and examine how technology affect people and the environment. They also learn techniques and methods that are used to solve technological problems. In the eight grade, students learn how to choose appropriate resources for te nological systems and how to process and control the systems to meet human wants and needs.

The Principles of Engineering course is one of the New York State approved electives in technology education for students in grades 9-12. The modules that compose Principles of Engineering constitute a one-year course organized around a set of major concepts, skills, and attitudes that are generic and necessary to all engineering endeavors. The major concepts, which are closely related to those of the ECCP project are: modeling, systems, optimization, technology-society interaction, design, and ethics.

The Technology Education Services Division of Virginia Department of Education, in summer of 1984, launched a three-year project in research and curriculum development for an Introduction to Engineering program for high school students. the project established an advisory committee, composed of industry leaders, engineering faculty, and NASA scientists and engineers, to advise the project personnel on curriculum development. The goal of the project was to develop an experimental curriculum which integrates the applications of mathematics and science into pre-engineering program of technology education.

Introduction to Engineering is a two-year program, and offers as high school elective. Course I, Challenge to Engineering, introduces students to engineering profession and careers, history of engineering, engineering communication and measurements, material science, computational tools, and engineering design process. Course II, Research and Development, emphasizes the applications of design process of engineering. Students from engineering teams and select a group project for designing an engineering product or device.

There were a number of studies in the U.S. and around the world in the 1990s that recommended the inclusion of engineering concepts as foundation for technological studies. A UNESCO report in 1990 suggests that "every person in all societies must have the advantage of a basic education which includes scientific and technological literacy." The National Research Committee on Science Education Standards and Assessment (1992) recommended the development of understandings of the concepts of engineering as the primary responsibility of the technology education curriculum at the primary and secondary school levels. Dugger (1994) stated that we need to develop a long term goal for what should be a direction and a vision for the intellectual content for the new "Engineering and Technological curriculum." A good example of such a new program is the DTEACH (Design Technology and Engineering for American's Children) program currently under development in the Austin School District in Austin, Texas. A review of the DTEACH subjects indicates that the subjects are very similar to the subjects taught at an undergraduate engineering level--mechanical (materials and mechanisms), electrical, electronic, industrial (time management), engineering economics (product life cycles), information processing and computer technology, and engineering design.

(Crawford, et al., 1994).

Project 2061. Let's now take a close look at the concepts of technological literacy proposed by AAAS in its Project 2061-- Science for All Americans and Benchmarks for Science Literacy. I believe that these concepts represent the best thinking on technological literacy today and will still be valid and relevant for the 21st century.

I. Major Theme

The component of technology is engineering. Engineering is the professional field most closely, or at least most deliberately, associated with technology. The best way to become familiar with the nature of engineering lies in Design and Technology Activities.

II. Design and Systems

1. Students should learn how to analyze situations and gather relevant information, define problems, generate and evaluate ideas, develop ideas into tangible solutions, and assess and improve solutions.

2. Students need to develop drawing and modeling skills, along with the ability to record their analyses and results in clear language.

3. The major design consideration is constraints.

4. The concept of trade-off in technology

5. The concept of feedback in technology.

6. Technologies always have side effects.

7. Technological systems can fail.

8. There is no perfect design

9. The solution to one problem may create other problems.

10. Control systems have inputs, outputs, and feedback. In almost all modern machines, microprocessors serve as center of performing control.

11. In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced and

disposed of.

12. Complex systems have layers of control

13. Risk analysis is used to minimize the likelihood of unwanted side effects.

14. To reduce the chance of system failure, performance testing is often conducted using small-scale models, computer simulators, and analogous systems.

III. Issues in Technology

1. The human presence: The human presence has caused great impact and developed the capacity to dominate the earth.

2. That capacity has both advantages and disadvantages.

2.1. Making other living organisms at risk
2.2. Energy consumption
2.3. Mining and manufacturing efforts and pollution
2.4. Nuclear energy

3. Technology and social interactions.

3.1. Social, political and economic focus strongly influences technological developments
3.2. Technology has strongly influenced the course of history and the nature of human society--population explosion, standard of living, urbanization and economic interdependence of communities, technological change, and social change.

4. Technological decisions are complex.

IV. Habits of Mind--Values, Attitudes, and Skills

1. Values and attitudes: curiosity, openness to new ideas, informed skepticism
2. Computation and estimation
3. Manipulation and observation

3.1. Storing and retrieving computer information
3.2. Using instruments to make measurements
3.3. Electrical connections
3.4. Using common tools and materials and electrical and mechanical systems

4. Communication
5. Critical-response skills: Applying critical skills to observation, arguments and conclusions

Based on the above review and the review of other literature, I have proposed an outline that suggests content for achieving technological literacy. The content of this outline is conceptually-based and covers the basic concepts of physical technology which is the basis of the Principles of Technology curriculum and fundamental to all engineering disciplines. It is design-oriented, applying a design methodology under constraints. It touches upon the technology-society interaction which is very important and highly critical in the educational experience for technological literacy.

Conclusion

Dr. James Benson (1993), President of Bemidji State University at Bemidji, MN, observes the current status of technology education in the U.S. as follows:

> Technology education as it has in the past, suffers from a lack of understanding, identity, respect, and acceptance. From its early start in the 19th century as manual training and up to the present, it struggles for its life. The state of affairs is especially disconcerting in light of the fact that we are currently experiencing the most robust period of technological development that society has ever encountered.

Kozak and Plummer (1994) explain the reason:

> The newly established industrial arts profession, however, could not focus on clearly defined objectives or common terminology. William E. Warner, at an AIAA conference, approximately 50 years ago, introduced five areas of curriculum: communications, construction, power, transportation, and manufacturing. Industrial arts professionals are still discussing these areas.

Kozark and Plummer warn the present-day technology education professionals:

> Technology education is at watershed; it cannot continue on its present course--because it is dying. Trying to be all things to all people, under the rubric of diversity, has resulted in technology education being "nothing to nobody."

Project 2061 has a similar observation:

Unfortunately, technology does not have a place in the general curriculum, so academic students fail to learn about technology and develop engineering problem-solving skills. Furthermore, the technology taught in technology-education classes (formerly industrial arts, and before that "shop") is often so single-mindedly vocational that teachers fail to teach about technology in social or scientific context.

Project 2061 is aiming at helping adjust both sides of that equation. That's why the theme of Project 2061 asserts that there is more profit in learning few things better than in learning more things poorly. They demand more of students in mathematics, science, and technology than is customary--more depth, more connectedness, more relevance. Project 2061 asks a very crucial question: "Who will develop and control the technologies so that they can best serve all citizens? In the broadest sense, the answer has to be for a democratic society--a technologically literate citizenry."

Paula Lawrence Wehmiller, a master teacher and principal, wrote that a school is "a gathering of gifts," meaning a place where everyone, from administrators and teachers of all disciplines to students, has something to offer. For educators in Taiwan, you have a great opportunity to gather your gifts. It may be the most important opportunity of your lives. The task ahead for technology education in Taiwan is to build engineering-based technological literacy into the school curriculum with the collaboration of the science and engineering disciplines so that all students possess basic knowledge and competencies associated with technology and become well informed about the nature, power, and limitations of technology. The author (Land, 1979) once wrote, "Educators dealing with the field of changing technology have a unique opportunity and responsibility in helping students to develop greater understanding of present problems and possibilities of the future. Educators need a concomitant refinement of established methodologies with careful evaluation and experimentation of the new and innovative ones to achieve the highest quality of instruction for students in a changing technological society." Time has changed, but the goal of education for technological literacy remains a great challenge. "The future (of technology education) is exceedingly bright for the proactive school system that takes the high road and brings in the engineering profession as a partner," said Benson and Benson (1993). I challenge the technology education profession in Taiwan to take the high road and turn your attention and resources to creating new ideas for technology education. I believe that you can create a national learning infrastructure that will serve the learning needs for technological literacy as we enter the 21st century.

THE FOLLOWING OUTLINE SUGGESTS CONTENT THAT MIGHT BE USED TO ACCOMPLISH THE GOAL OF TECHNOLOGICAL LITERACY

I. Introduction to Technology

1. Technology Satisfies Human Needs
   1.1. Physical Technology (Fundamentals of Engineering)
      A. Mechanical
      B. Electrical
      C. Thermal
      D. Fluid
   1.2. Electronic and Computer Technology
2. Technology Has Evolved over Many Years
   2.1. Early Technologies: Tools, Fire, Wheel and Axle
   2.2. Developments and Innovations: Metallurgy, Electricity, Computers
3. Technological Time Line
   3.1. Structural Age (2900 B.C.-)
   3.2. Mechanical Age (1700-)
   3.3. Electrical Age (1879-)
   3.4. Information Age (1906-)
   3.5. Socioengineering Age (1979-)

II. Technological Resources

1. People: Labor, Management, Consumer
2. Tools and Machines: Hand Tools, Manual Machines, Automated Machines
3. Materials: Natural, Processed, Renewable, Nonrenewable, Synthetic
4. Capital:Exchange and investments
5. Energy
   5.1. Forms: Radiant, Mechanical Electrical, Chemical, Thermal, Light, Magnetic
   5.2. Sources: Forces, Fossil Fuels, Water, Solar, Wind, Nuclear, Geothermal
6. Time: Human Limitations, Natural Constraints

III. Electrical Engineering

1. Definitions
2. Ohm's Law
3. Resistors in Series
4. Resistors in Parallel
5. Current and Voltage
6. Power Dissipation in Resistors
7. Power supplied by Batteries
8. Kirchhoff's Voltage Law

IV. Mechanical Engineering

1. Forces
2. Resultant
3. Moments

4. Free-Body Diagrams
5. Equilibrium
6. Trusses
7. Velocity and Acceleration
8. Newton's Second Law
9. Work and Energy
10. Kinetic and Potential Energy
11. Power
12. Stress
13. Strain
14. Material Properties and Hooke's Law

V. Thermal Engineering

1. Energy
2. Units of Energy, Work, and Power
3. Specific Heat
4. Heating Values of Fuels
5. Conversion of Energy and Work
6. First Law of Thermodynamics
7. Second Law of Thermodynamics

VI. Fluid Engineering

1. Pressure
2. Manometers
3. Forces on Submerged Surfaces
4. Buoyancy
5. Equation of continuity

VII. Electronics and Computers

1. Basic Concepts of Electronics
2. Electronic Components and Circuits
3. Computers
4. Computer Systems
5. Computer Hardware
6. Computer Software--Word Processing, Database Management, CADD, Telecommunication, Networking, Specialized Applications

VIII. Problem-Solving and Engineering Design

1. The Design Process
   1.1. Identify and Define Problem
   1.2. Set Goal and Criteria (Desired Outcomes)
   1.3. Generate Alternate Solutions
   1.4. Select Best Solutions (Optimization)
   1.5. Evaluation and Modification
   1.6. Implementation
2. Optimization

2.1. Trade-Off
2.2. Risk Analysis
3. Modeling
3.1. Physical Models (Prototype and Scaled Model)
3.2. Computer Simulation
3.3. Mathematical Model
4. Design Communication
4.1. Sketching
4.2. Design Drawing
4.3. Pictorial
4.4. Schematic
4.5. CADD
4.6. Technical Report and Oral Presentation
5. Constraints and Limitations of Technology
5.1. Natural Constraints
5.2. Human Limitations

IX. Controlling Technological Systems

1. Open-Loop vs Closed-Loop Control
2. Using Feedback
3. Sensors: Electrical, Electronic, Optical, Thermal
4. Comparators: Mechanical, Electrical, Electronic
5. Controllers: Mechanical, Electrical, Electro-Mechanical, Pneumatic, Hydraulic
6. Program Control: times; Computers
7. Computer Control

X. Technology-Society Interaction (Impacts of Technology)

1. Engineering Ethics
2. Population Growth
3. Energy and Global Resources
4. Environmental Issues: Waste Disposal, Nuclear, Pollution
5. Technology and Health Care
6. Technology, Work, and Leisure
7. Searches for Alternatives

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由工程的觀點看科技素養

作者：藍敏慧博士

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世界正因科學與科技的進展而快速地改變，而這些改變對民主社會中的經濟利益有深遠的意義。世界變遷的主要衝擊之一是工作將需要許多科學與科技的能力，以及對演化中的知識體與新機會需要修正技術時，具備高度的彈性與調適能力。為了要成功地參與快速變遷的世界經濟，我們的社會將比以前任何時期，更需要擁有具備更多技術與適應力的公民與工作人力。世界性的教育改革認為科學與科技素養是一般公民所需具備的最重要基本素養，這些基本素養將使所有人都可成為社會完全參與的公民和有生產力的工作人員。科技教育所面臨的挑戰在於發展對科技素養內涵的看法與架構，以及設計與建構可提升科技素養的課程。

科技教育與科養技素

早期的科技素養概念

雖然就教育的發展而言，科技素養的概念相對上是一個新的名詞，但杜威在其一九一六年所著的民主與教育一書中即曾表達他對科技素養的看法：

> 值得一提的是，在人類進展的歷史中，科學是由社會上有用的行業中漸漸地發展出來。物理學由人類使用工具與機器的經驗中慢慢地發展出來；機械力學是物理學的重要學派之一，

由機械力學的名稱即可看出物理與人類使用工具與機械的原始關係。因為是人類為解決實際問題的過程中所產生的，因此才更突顯出槓桿、輪子與斜面等原理的應用，是人類早期重要智慧結晶的意義。

杜威更進一步地提倡植基於工業行業（科技）的科學與科技素養教育，他進一步地指出：

工業長期停留在是一種實證的、基於經驗與一般常識的程續、由傳統中流傳下來的刻板印象中。然而工業的技術現在是科技的，因為現在的工業是建構在應用數學、物理、化學等發明的機械上。經濟革命藉由探究實際的問題解決以及生產更聰明的機械產品而刺激科學的發展。而且工業也自科學的發展得到複利性的回收，因此現在的工業行業比以往更具有無限大的智慧性內容，以及較它們過去所擁有無限大的文化的可能性。對這類教育的需求使工作者熟悉科學的與社會基礎的變成重要的，因為未具備這些科技素養的工作者無可避免地將成為他們所操作的機器的附屬物。

他並對科技素養作了以下的結論：

有關於材料、工具、以及能源定律的技能與知識的是透過與他們切身有關的活動而獲得的。事實上，如這些活動是社會的代表性活動，將可使所學習的知識與技能具有遷移到校外的情境中的功能。

學習教育史的學生都知道，杜威非常反對聯邦政府與州政府對教育的立法，立法將建立起個別獨立的職業教育與普通教育。為此，他極力地提倡一種以教導當時非常流行的名詞—工業智慧為目標的新式的工業教育，作為普通教育改革的一部份，而現在我們稱工業智慧一詞為科技素養。杜威在一九一七年對工業智慧定義為：一種對現在製造、運輸、以及商業的情況與過程的知識，使得個人有能力作出自己的選擇與調適，至少在有生之年作自己命運的主人。

美國工藝教育學會(AIAA)與國際科技教育學會(ITEA)

從科技教育專業人員的觀點而言，第一個對介紹以科技素養為主的科技教育的真正衝擊來自一九四七年。一九四七年俄亥俄州立大學(The Ohio State University)的華納(Warner)博士與一群他指導的研究生，在美國工藝教育學會年會中所倡導的「一種反映科技的課程」，在他們所提出的課程中，引介傳播、營建、動力、運輸、與製造等五個科技領域作為工藝教育的學習領域，以替代在職業領域中的手工以及工藝教育中的木工、金工、製圖、印刷、等單元工作的學習。在其後以及直到現在的工藝教育與科技教育的課程改革，大都深深地受到這一課程概念的影響。根據吉伯特(Gilberti)一九九四年指出，在中學的一般科技教育課程仍包含上述五個領域以及無數的課程：

中學常見的科技教育課程

- 傳播
  - 傳播科技導論
  - 設計／製圖
  - 攝影
  - 圖文工
  - 遠距傳播
- 製造
  - 製造科技導論
  - 材料處理
  - 電腦輔助製造
  - 生產科技
- 運輸
  - 運輸科技導論
  - 航空科技
  - 空中運輸
  - 水域運輸
  - 太空運輸

陸路運輸

營建

營建科技導論
營建材料處理
建築製圖
商業／住宅營築

能源與動力

能源與動力科技導論
替代性能源
電力控制科技
電子學
工業機器人原理

高階課程

研究與發展
科技的應用
創新與發明

在華納博士的指導下，奧森(Olson)在其名為科技與工藝(Technology and Industrial Arts)的博士論文中建議在工藝教育中探討科技，在他一九六三年所著的工藝與科技(Industrial Arts and Technology)一書中，奧森強調在工藝教育運用科技的挑戰作為學生的性向與應用的發現與發展的來源。一年之後，迪伯爾(DeVore, 1964)寫了一篇深具影響力的文章，該文章名為科技：一個智慧的學門(Technology: An Intellectual Discipline)，該文章成為今日科技教育課程發展的原始架構。

Snyder與Hales一九八一年所發表的傑克森坊(Jackson's Mill)工藝課程理論，被許多科技教育專業人員認為是一九八Ｏ年代科技教育課程的重要文獻，傑克森坊II(Jackson's Mill II)進一步地修正原來傑克森坊的課程概念，在傑克森坊II中將製造科技與營建科技合併成為生產科技，並將生物科技納進科技教育課程範疇內。

在一九九O年代，國際科技教育學會將科技教育的首要任務—科技素養的概念引介給科技教育專業人員，在國際科技教育學會一九九O至一九九五年的專業發展計畫中，對其任務陳述如下：

國際科技教育學會的任務在於提升科技素養。為達成此一任務，國際科技教育學會挑戰其會員從事：

一、提供以強調科技素養的科技研習的哲學基礎

二、提供發展科技素養的教、學系統

三、培養研究與提升科技素養

科技素養的定義

科技教育學會所出版的第四十年年刊，是以探討科技素養為主題的專刊，直到今日該年刊仍是探討科技素養相關論題最具代表性的著作。科技素養被定義如下：

> 科技素養是多向度的名詞必要包含使用科技的能力（實際應用層面）、了解因科技或使用科技相關論題的能力（公民層面）、以及對科技意義評估的能力（文化層面）(Dyrenfurth, 1991)。

明尼蘇答大學職業與技術教育教授普賽爾(Pucel)長期持續地倡導科技素養。一九八九年，在他在科技與社會期刊(Journal of Technology and Society)所發表的文章裡，建議將科技素養列為工藝教育的目標與角色。在他最近所寫(1995)刊載於科技教師(The Technology Teacher)的文章裡，對科技素養定義如下：

> 具備對科技演化與革新的了解，以及應用工具、設備、構想、過程與材料，以滿意的解決方案滿足人類需要的能力。

此一定義是基於具備科技素養的人的兩項特徵為（一）他們了解科技的方法(technological method)，（二）他們透過使用工具、設備、構想、過程與材料的經驗而發展出基本的「常識」(common sense)層次的科技知識的假設上。

對國際科技教育學會倡導科技教育的回應，國立臺灣師範大學李隆盛博士在一九九一年在中央日報的文章中，提出將臺灣的工藝教育更名為科技教育的建議。在文章中，他指出工藝教育的主要目的為加強學生的科技素養，他描述人類生活在科技的的環境中。當我們無論是面對一個家庭、一間辦公室、或者是透過打開的窗户觀察外面的景觀，我們所看到的是經科技修飾過的人造物。工程與科技對開創現代歷史具有重大的貢獻，科技教育提供堅實的科技基礎，以協助學生在往後的科技世界中生活。

給全美人民的科技

在國際科技教育學會的倡導下，在一九九四年由維吉尼亞技術大學的道格(Dugger)博士的領導下，開始一項由美國國家科學基金會(National Science Foundation, NSF)與國家航空太空總署(National Aero and Space Administration, NASA)提供經費補助，以提供科技素養：變遷世界中的擴展能力為核心任務的給全美人民的科技(Technology for all Americans)的研究計畫，該計畫是有史以來提供給科技教育最大筆的研究計畫。該計畫第一階段主要目的在於發展科技研究的哲學理論基礎與結構，以及建立全國對科技教育的共識。而該計畫在一九九六年開始的第二階段，則將發展幼稚園至高中(grades K through 12)的科技教育課程標準，以及師資培育的課程標準。完成以

後，此計畫將提供對發展有關科技教育如何與科學、數學、工程、以及其他學科互動的最新的研究發現與創新的構想重要洞察力。

科學、工程與科技素養

工程導向

科技素養同樣是科學與工程學門的焦點。可追溯至三十一年前，在布魯克林綜藝學院(Polytechnic Institute of Brooklyn)主導下，一個名為「人造的世界：工程概念課程計畫(Engineering Concepts Curriculum Project, ECCP)的中學課程，該課程計畫倡導科技素養是給所有人的主要教育目標：

> 雖然ECCP提供特殊的教育目標給老師來評量他們的教學績效，但該計畫的真正課程目標是發展科技素養。

ECCP計畫的作者們在三十年前即警告地說「我們國家所面臨的問題是永久的，我們不止需要了解科技，我們更須留意它的副作用。」，現在的改變相當快速，但其可見的影響卻經常遲緩到在其效應可扭轉之前，錯誤的決定可能已導致重大的問題的出現。ECCP計畫建議大學前的教育應讓學生具備：

一、應用科技來提升許多與科技相關的個人及專業決定的決策品質
二、熟悉並智慧地參與由工業社會轉變成為後工業服務與資訊時代
三、更主動地參與通常包含運用複雜科技的公共政策的決策

為了要達成加強科技素養的目標，ECCP計畫小組出版兩本書作為在中學科技教學的基礎。第一本書是<u>人類與他的科技(Man and His Technology)</u>，該書透過諸如服務人類的科技、決策、最佳化、模型製作、系統、變遷的模式、回饋、穩定、以及機器與系統等單元的介

紹，來探討一九七零年代基本的科技概念。在第二本書，人類與他的科技：問題與論題(Man and His Technology: Problems and Issues)，則包括系統與決策、人口、健康服務、緊急事件、決策、能源危機、噪音、以及環境等九個單元。

科學與科技素養

一九八三年，美國國家科學委員會之大學前數學、科學與科技教育委員會(The National Science Board Commission on Precollege Education in Mathematics, Science and Technology, 1983)批判美國的學校教育並未提供適切的科技教育，並敦促美國教育體系透過（一）一種一年的特殊課程來探討科技概念，與（二）從幼稚園至中學，透過其他的教學主題整合科技等兩種途徑，來發展一綜合且反映現代科技內涵的科技教育。由該委員會建議的科技能項目即可反映出，該委員會所倡導的科技教育課程受到ECCP計畫深遠的影響，該委員會建議的科技能項目包括：

一、形成與解決問題並辨認解決問題的替代方案

二、聯結理論與實務，建構並測試模型

三、檢核交易與風險分析，綜合與設計

四、運用回饋與穩定性的概念

作者本人(Land, 1984)在一九八四年一篇刊載在科技教師期刊的文章中，回應該委員會的呼籲並敦促科技教育的專業人員與國際科技教育學會，為提供科技教育給所有美國學校，肩負起更多的領導與責任，同時本人並提出如果科技教育專業人員無法肩負起領導的角色並

接受此項挑戰，則其他領域（例如科學、數學、及初級工程課程等領域人員）將接手此一重要任務的警告。

在一九八五年，也正是哈雷彗星最接近地球的那一年，美國科學促進會(American Association for the Advancement of Science, AAAS)為二十一世紀，執行一項名為「2061計畫」(Project 2061)的綜合且長程的措施來改革科學、數學以及科技教育。為何使用2061呢？因為哈雷彗星的週期大約為七十六年，約略等於已開發國家國民的平均壽命。因此，我們可預期大約有一半在一九八五年出生的人可在2061年見到下一次哈雷彗星的來臨。「2061計畫」預測在2061年時的生活品質將取決於這一代國民與下一代國民所接受的教育上。「2061計畫」認為年輕的一代在離開學校時必須具備良好的科學、數學、以及科技教育，一種可使他們智慧地參與科學活動，並成為社會中可靠的和有生產力的成員的教育。此外，教育必須協助他們對不確定的未來作準備，也因此教育必須包括心智的了解與心智習慣鍛鍊，因其可作為解決終其一生所面臨的[illegible]的工具。

為達成科學、數學、與科技教育的目標，「2061計畫」以兩階段的方式推展相關活動。第一階段在一本名為給全美人民的科學(Science for All Americans)，闡述下一代所必須了解的科學、數學、與科技知識，第二階段則在名為科學素養的標準(Benchmarks for Science Literacy)的書中，將第一階段的學習目標轉換成新的課程概念。包含科技素養的科學素養被如下地定義：

> 科學素養。一個具備科學素養的人是一個受過教育的人，一個擁有某些知識或能力的人。但是當然，有關用什麼樣的知識與能力，來精確地定義素養的法則持續地變動，在今日的世界，成人所需的素養涵蓋與科學、數學、以及科技相關的知識與能力。「2061計畫」已著手進行確認人類如果要在科學、數學、以及科技為核心的文化中，過著有趣的、可靠的、與有生

產力的生活所需的知識與心智習慣的工作。也就是描述構成科學素養的內涵…，科學素養加強一個人對事物的洞察力，對事物作深思與熟慮，並理解對事物的解釋。此外，這些內在的洞察力與深思熟慮，可提供作為個人作選擇與採取行動的決策基礎。

葛瑞(Gray, 1988)博士，一位傑出的科學家、工程師、以及前麻省理工學院校長，也強烈地倡導科學的素養，他警告美國對科學與科技的忽視，不但將導致對經濟活力打擊，同時也會對民主的過程產生威脅。他敦促中小學與大專院校，提供涵蓋人文、科學與科技，廣泛且綜合知識的新課程。

在一九八八年，國際科技教育學會與許多諸如國家科學基金會(NSF)、美國科學促進會(AAAS)等專業與學術團體，共同組成國家科學、科技與社會學會(National Association for Science, Technology and Society, NASTS)，從那時候開始，NASTS每年資助名為科技素養會議的年會，該年會提供與會者與來自全美以及世界其他區域對關心社會所面臨的科技與科學論題人士見面的機會。

近年來，國家科學基金會已提供兩個整合中學階段科學、數學與科技教育的研究計畫，其中之一是伊利諾州立大學的研究計畫，另一個則是維吉尼亞技術大學所進行名為科技／科學／數學整合(Technology/Science/Mathematics Integration)的計畫。該計畫已發展超過40個活動給科技、科學、與數學老師來整合6-8年級學科教學內容。

「科技的原理」(Principles of Technology, PT)是提供給對技術工作生涯有興趣的職業教育學生，以及其他對現代科技作用原理有意深入了解的中學生。「科技的原理」是由美國42個州的職業教育機構、加拿大的Alberta/ACCESS network、位於印第安那布魯明頓的非營利的美加教學科技(American-Canadian Agency for Instructional

Technology, AIT)、以及位於德州瓦克的行業研究發展中心(Center for Occupational Research Development, CORD)所共同合作發展的課程。「科技的原理」包括十四個教學單元，每個單元探討一個應用在機械、電力、流體、與熱能等四個科技系統且可建構成簡單與複雜的科技元件與設備的原理。一般而言，這些單元需使用兩年的時間來並以下列的順序來介紹：

第一年單元包括：力、功、比率、阻力、能量、功率以及力的轉換器等單元。

第二年單元包括：動量、波動與震動、能量轉換器、電功率轉換器、輻射、光學系統、時間常數等單元。

「科技的原理」導源於職業教育，因此它並不是一個實施科技教育的課程。然而正如麥凱德(McCade, 1991)對它所作的敘述，「當你更深入地學習「科技的原理」，從事科技教育的你我，將更強烈地採取「科技的原理」有許多值得我們學習的結論。」，麥凱德進一步地說明：

> 「科技的原理」在發展繼續學習科技的基礎方面優於許多科技課程的教學內容，『科技的原理』以有組織的結構，協助學生發展對科技共通概念的了解，而就算是標示著科技教育的課程，卻往往介紹短時間即過時的技能。科技的共通概念並不會過時，而且共通的概念可作為終生的科技素養學習的基礎。

工程導向的科技教育

紐約州的科技教育課程，是美國一個融合數學、科學、並整合工程概念在其教學內容的代表性的科技教育課程。在一九八四年三月，紐約州的議會通過法案，規定每一個學生在第八學年結束前，必須修

完一年的科技教育課程，因此在紐約州的中學，一般都在第七學年與第八學年各提供半年的科技導論課程。在第七學年，學生探討科技的發展與演進史，並強調諸如自然科學的、生物的、資訊與傳播等主要的科技領域。學生學習科技的系統及其子系統，並檢視科技如何影響人類與環境，學生同時可學習用來解決科技問題的技術與方法。在第八學年，學生學習如何針對科技系統選擇適當的資源，以及如何處理與控制科技系統以符合人類的需求與需要。

工程的原理(The Principles of Engineering)課程是經州政府審核過，提供給9-12年級學生選修的科技教育選修課程之一。工程的原理課程由許多模組組成，課程組織環繞著以一組所有工程領域類似且需要的主要概念、技能與態度的學習。工程的原理所提供的主要概念與ECCP計畫有密切的關係，其主要概念包括：模型製作、系統、最佳化、科技與社會互動、設計、以及倫理等。

維吉尼亞州教育局的科技教育部門在1984暑間，開始一項以中學生工程導論課程為對象的三年研究與課程發展計畫，該計畫成立一個以工業領袖、工程相關領域教授、以及航空太空總署的科學家與工程師所組成的諮詢委員會，對計畫工作人員提出有關課程發展的建議，該計畫的目的在發展一個將數學與科學的應用，整合進入科技教育的工程準備教育實驗課程。

工程導論是高中一個為期兩年的選修課程，第一年的課程包括對工程的挑戰、工程專業與生涯的簡介、工程的歷史、工程溝通與測量、材料科學、計算的工具、以及工程設計過程等主題。第二年的課程包括研究與發展、強調工程設計過程的應用，學生組成工程小組並選擇一項小組作業，來設計一個工程的產品或裝置。

在一九九０年代，許多美國及世界各地的研究建議融入工程概念作為科技研習的基礎。一份在一九九０年由聯合國文教組織(United

Nations Educational, Scientific, and Cultural Organization, UNESCO)所提出的研究報告建議「在所有社會的每一個人，必須因接受涵蓋科學與科技素養的基本教育而獲得利益。」國家科學教育標準與評量研究委員會(The National Research Committee on Science Education Standard and Assessment)建議在小學與中學階段，發展對工程概念的理解，是科技教育課程的主要責任。道格(Dugger, 1994)指出，我們需要為新的工程與科技課程的智慧內容的方向與定位發展長程目標，DTEACH(Design Technology and Engineering for American's Children)為應用此一概念的好例子，DTEACH課程現正由德克薩斯州奧斯汀學區發展當中。當我們瀏覽檢閱DTEACH的課程內容即可發現，它的教學內容與大學工程科系所教授的內容很類似，教學內容包括機械的（材料與機構）、電的、電子的、工業的（時間管理）、工程經濟學（產品生命週期）、資訊處理與電腦科技、以及工程設計等(Crawford, et al., 1994)。

2061計畫

現在讓我們更仔細地檢視由美國科學促進會(AAAS)的2061計畫，在給全美人民的科學(Science for All Americans)與科學素養的標準(Benchmarks for Science Literacy)中所建議的科技素養概念，我相信這些概念，不但是現在最具代表性科技素養，而且對二十一世紀而言，這些概念也將是有效與適切的。

壹、主題

工程是科技的必要部分，工程是與科技最接近的或至少是最嚴謹的相關專業領域，透過設計與科技的活動是與工程本質熟悉的最佳方法。

貳、設計與系統

一、學生必須學習如何分析情況與蒐集適切的資訊、定義問題、產生並評估構想、發展構想成明確的解決方案、以及評估和改良解決方案。

二、學生必須發展繪圖與製作模型的技能，以及具備以清晰的語言記錄他們的分析與結果的能力。

三、設計的主要考慮事項是限制。

四、在科技中的妥協(trade-off)。

五、科技中的回饋。

六、科技通常都有副作用。

七、科技系統可能失效。

八、完美的設計並步存在。

九、對某一個問題的解決方案可能製造出另外的問題。

十、控制系統包括輸入、輸出與回饋，幾乎所有的現代機器，都由微處理機扮演著控制中心的角色。

十一、在設計一個元件或過程中，必須思考此項設計該如何地製造、操作、更換與安置。

十二、複雜的系統具備多層次的控制。

十三、風險分析是用來降低不需要的副作用的可能性到最小的程度。

十四、通常運用縮小模型、電腦模擬、以及類比系統從事測試的工作，以降低系統失效的機率。

參、科技的論題

一、人類的出現：人類的出現造成很大的衝擊並發展成主宰地球的能力。

二、主宰地球的能力有其優點與缺點。

1. 使其他生物處於危險的狀況下
2. 能源消耗
3. 礦藏開採、製造活動與污染
4. 核能

三、科技與社會互動

1. 社會、政治、與經濟的重點，深深地影響科技的發展
2. 科技深深地影響歷史的進展與人類社會的本質，如人口爆炸、生活水準、都市化與社區間經濟的相互依賴、科技變遷、以及社會變遷。

四、科技的決策是複雜的

肆、心智的習慣—價值、態度、與技能

一、價值與態度：好奇、對新構想的開放態度、了解後的批判

二、計算與估計

三、操控與觀察

1. 存、取電腦資訊
2. 使用量測工具測量
3. 電力連接
4. 使用一般工具、材料、電力的與機械的系統

四、溝通

五、批判的—反應技能：應用批判的技能於觀察、討論與結論

基於以上及其他的文獻探討，我將達成科技素養的建議內容摘要下來，摘要的內容是以概念為基礎的並且包括物理科技的基本概念，而這些概念正是『科技的原理』的基礎，而且也是所有工程學科的根本。它是設計導向，在限制的條件下運用設計的方法，它必須觸及科技與社會互動的層面，科技與社會互動在科技素養教育的經驗上是非常的重要的。

結論

麥森(Benson, 1993)，明尼蘇答州Bemidji州立大學校長，對現在美國的科技教育持以下的看法：

> 科技教育跟它以前一樣，因為缺少了解、正名、尊敬以及接受而遭受傷害，從十九世紀之初的手工訓練到現在的科技教育，科技教育一直都在為自身的生存而掙扎。但是事實的情況是，大眾卻非常不關心我們的社會正處於前所未有的、且最強而有力的科技發展時代。

柯瑞克與普拉摩(Kozak & Plummer, 1994)説明其理由為：

> 然而，新近建立的工藝專業，無法將焦點集中在定義明確的目標上或者是一般的專業名詞上，約五十年前，瓦那(Warner)在美國工藝教育學會的年會中引介傳播、營建、動力、運輸與製造等五大課程領域，現在工藝教育專業人員依舊是討論著這些領域。

柯瑞克與普拉摩對今日的科技教育專業人士提出忠告：

> 科技教育正處於轉捩點上，它無法持續現在的發展，是為它正處於垂死狀態。試著對所有的人提供所有需要的事物，在所謂多樣化教條的束縛下，科技教育卻落到任何人都一事無成的地步(nothing to nobody)。

2061計畫對科技教育亦有類似的看法：

> 很不幸地，在普通教育課程中科技並無容身之地，因此有學術傾向的學生，無法學習科技相關概念並發展工程的問題解決能力。進一步地說，在科技教育課程（以前叫做工藝或更早以前叫工場課）所教導的科技，一般都過分單純地以職業的角度從事思考與教學，老師並未以社會的與科學的環境背景觀點來教導科技。

2061計畫試圖協助科技教育取得平衡點，這也正是該計畫為什麼堅信學習較少的事物，反比樣樣都學卻事事無成來得好。他們要求學生在數學、科學、與科技上比平常投入更多的、更深入的、更相關、以及更切要的學習。2061計畫提出一個非常關鍵的問題：「誰將發展與控制科技，使科技能對所有的人提供最好的服務？廣義地說，上述問題的答案在於一個民主的社會—在於一群具備科技素養的人民。」

惠米勒(Wehmiller) 是一位教學名家與校長寫道，學校是「才能的蒐集」(a gathering of gifts)，意思也就是說，它是一個上自行政人員、各學科師下至學生，每一個人都可給予某些事物的地方。對臺灣的教育工作者而言，你們有很好的機會去蒐集你們的禮物，這或許是你一生中最重要的機會。臺灣科技教育後續的任務是，在科學與工程相關人員的協同合作下，將植基於工程的科技素養納入學校的課程之中，如此才可使得所有的學生擁有科技相關的基本知識與能力，以便使學生充分地了解科技的本質、力量與限制。本人(Land, 1979)曾寫過，「教育工作者論及變遷中的科技領域時，在協助學生對現在

的問題與未來的可能性發展更深入的認知上，有獨特的機會與責任。為在變遷的科技社會中的學生，教育工作者需透過細心的評估和實驗對待新的或革新的事物，對現有的方法加以精緻化，以達到教學的最高品質。」時間已改變了，但培養科技素養的教育目標仍舊是一項重大的挑戰。班森曾說(Benson and Benson, 1993)，「對有先見之明、採取捷徑，將工程專業人士納為工作伙伴的學校系統而言，（科技教育的）未來是非常光明的。」我鄭重地建議臺灣的科技教育專業人士採取捷徑，並將你們的注意力與資源，移轉到科技教育新構想的開創上，我相信你們可開創出一個符合我們在21世紀時的科技素養學習需求的全國學習架構。

下列綱要建議可用來達成科技素養目標的內容

壹、科技導論

一、科技滿足人類的需要

1. 物理科技（工程的基礎）

(1)機械的

(2)電的

(3)熱的

(4)流體的

2. 電子與電腦科技

二、科技經過長時間的演進

1. 早期的科技：工具、火、輪子與輪軸

2. 發展與革新：冶金學、電學與電腦

三、科技的時間順序

1. 建築時代(Structural Age, 2900 B.C.-)

2. 機械時代(Mechanical Age, 1700-)

3. 電力時代(Electrical Age, 1879-)

4. 資訊時代(Information, Age, 1906-)

5. 社會工程時代(Socioengineering Age, 1979-)

貳、科技的資源

一、人類：勞動力、管理與消費者

二、工具與機器：手工具、手工操作機器與自動化機器

三、材料：自然的、處理過的、可再生的、不可再生的、合成的

四、資金：交易與投資

五、能源

1. 形式：輻射、機械、電力、化學、熱力、光與磁力

2. 來源：力、石化燃料、水、太陽、風、核子與地熱

六、時間：人類的極限與自然的限制

參、電機工程

一、定義

二、歐姆定律

三、串聯電阻

四、並聯電阻

五、電流與電壓

六、電阻能量耗損

七、電池供電

八、克希荷夫電壓定律

肆、機械工程

一、力

二、合力

三、力矩

四、分離體

五、平衡

六、架構

七、速度與加速度

八、牛頓第二定律

九、功與能量

十、動能與位能

十一、動力

十二、應力

十三、應變

十四、材料性質與虎克定律

伍、熱力工程

一、能量

二、能量、功與動力的單位

三、比熱

四、燃料的熱值

五、熱與功的轉換

六、熱力學第一定律

七、熱力學第二定律

陸、流體工程

一、壓力

二、壓力計

三、液體中的表面壓力

四、浮力

五、連續方程式

柒、電子學與電腦

一、電子的基本概念

二、電子元件與迴路

三、電腦

四、電腦系統

五、電腦硬體

六、電腦軟體—文書處理、資料庫管理、CADD、遠距通訊、網路、特殊應用

捌、問題解決與工程設計

一、設計過程

1. 確認與定義問題
2. 設定目標與標準（期望的結果）
3. 產生替代方案
4. 選擇最佳解決方案
5. 評估與修飾解決方案
6. 執行（實現）解決方案

二、最佳化

1. 交易妥協
2. 風險分析

三、模型製作

1. 實體模型（原型與比例模型）
2. 電腦模擬
3. 數學模式

四、設計溝通

1. 草圖
2. 設計圖
3. 插圖
4. 示意圖
5. 電腦輔助設計製圖
6. 技術報告與口語發表

五、科技的限制

1. 自然的限制

2. 人類的極限

玖、科技系統的控制

一、開敞循環系統與閉迴路控制

二、回饋運用

三、感知器：電力的、電子的、光的與熱的

四、比測儀：機械的、電力的與電子的

五、控制器：機械的、電力的、電機的、氣動的與液壓的

六、程式控制：時間、電腦

七、電腦控制

拾、科技與社會的互動（科技的衝擊）

一、工程倫理

二、人口成長

三、能源與全球資源

四、環保問題：廢棄物、核子、與污染

五、科技與保健

六、科技、工作與休閒

七、尋找替代品

Implementation of Technology Education in Japan

(Revised Edition)

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Introduction

This paper is prepared for the International Workshop on Technology Literacy and Technology Education held in 1996 at NTNU. The original paper was published in 1993 in the USA. (Journal of Technology Education Vol. 5 No.1,pp29-37. by Shoji Murata & Sam Stern). Supplements by one of authors describing recent developments, are included here.

In the primary school, there is no independent subject for technology literacy, however, there are technology literacy related subjects: "Seikatuka [Life]", "Zuga-Kosaku [Arts and Craft]", "Rika [Science]" and "Kateika [Home economics]".

In the lower secondary level, there is an independent subject named "Gijutu-kateika" [Industrial Arts/Technology and Home economics]".

In upper the secondary level, there is no independent subject; however, subject in Home economics named "Seikatugijutu [Life technology]" has been established. The more noteworthy institutional change is the establishment of a new course named "Sogogakka [Integrate Course]". The integrated Course aims to promote career development/technological literacy and to integrate general and vocational education.

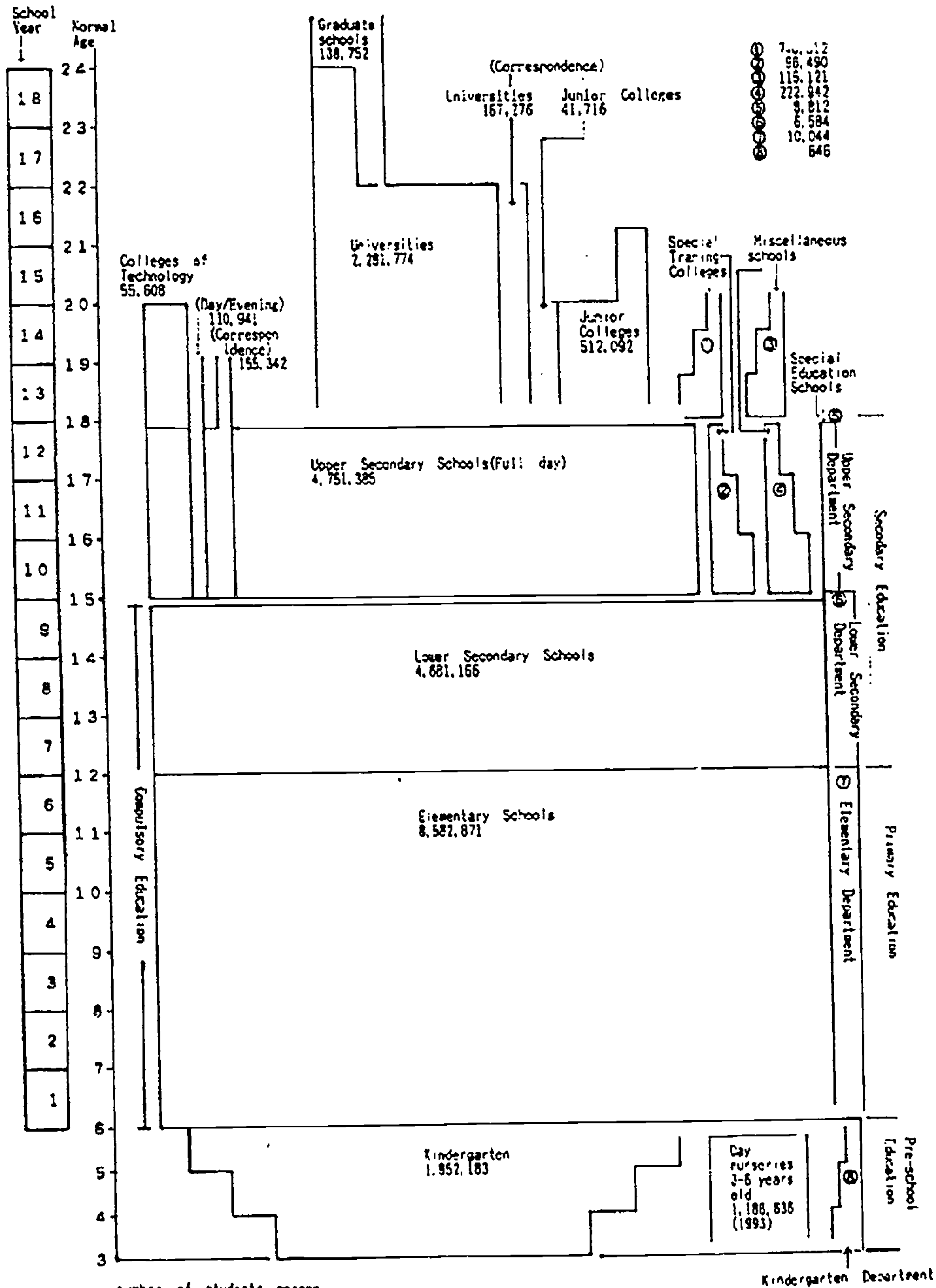
This paper focuses on technology education at the secondary level.

1. An Overview of the Japanese Educational System

In recent years, Japanese industrial and educational practices have received worldwide attention. In spite of the interest in Japanese industry and education, there has been relatively little study of technology education in Japan. This paper describes the history and current status of technology education in Japan. Because of their close relationship, discussion of both technology education at the lower secondary level, gijutsuka, and vocational technical education at the upper secondary and post-secondary level, shokugyo kyoiku, are included in this paper.

The structure of public education in Japan is largely based on the American model of education which was adopted after World War II. Figure 1 shows the major types of publicly supported schools. The foundation of the modern Japanese educational

Figure 1. Organization of Japanese Present School System



number of students, person
Note: Date on school education is from May 1, 1994
Date on Day nurseries is from Octber 1, 1993 by Ministry of Health and welfare

Table 1 Characteristics of each type of school

Type of School or Course		Main Type of Establishing Body*	Qualifications for Admission	Duration of Course (in years)	Requirement for Graduation
Kindergarten	One-year course	Private Municipal	Age of 5	1	–
	Two-year course		Age of 4	2	
	Three-year course		Age of 3	3	
Elementary School		Municipal	Age of 6	6	Completion of six-year course
Lower Secondary School		Municipal	Completion of elementary school course Age of 12	3	Completion of three-year course
Upper Secondary School	Full-day course	Prefectural Private Municipal	Graduation from lower secondary school Age of 15 or more	3	Acquisition of 80 credits or more
	Day/evening course			3 or more	
	Correspondence course			3 or more	
Special Education School	Kindergarten, elementary, lower secondary and upper secondary departments	Prefectural Municipal	Same as in kindergarten, elementary, lower secondary and upper secondary schools, respectively		
College of Technology		National	Graduation from lower secondary school Age of 15 or more	5	Acquisition of 167 credits or more (incl. 82 credits or more for specialized subjects) **
Junior College	Two-year course	Private Prefectural National	Graduation from upper secondary school Age of 18 or more	2	Acquisition of 62 credits or more **
	Three-year course			3	Acquisition of 93 credits or more **
University	Bachelor's course	Private National	Graduation from upper secondary school Age of 18 or more	4 or more**	Acquisition of 124 credits or more **
	Master's course	Private National	Bachelor's degree	2 or more	Acquisition of 30 credits or more ** Passing the examination of master's thesis and test
	Doctor's course			5 or more**	Acquisition of 30 credits or more ** Passing the examination of doctoral dissertation and test
Special Training College	Upper secondary course Postsecondary course General course	Private	Completion of lower secondary schooling Completion of upper secondary schooling	1 or more	–
Miscellaneous School		Private	Completion of lower secondary schooling Completion of upper secondary schooling	3 to 12 months or 1 year or more	–

* Sequence indicates frequency. For the percentage distribution of schools by establishing body, see the chart on page 23.

** See the chart on page 77.

system is the nine-year compulsory education core, gimu kyoiku. Included in the compulsory core is a six-year elementary school, shogakko, and a three-year lower secondary school, chugakko. Practically all (almost 100%) of Japanese students complete compulsory education. After completing compulsory education, the vast majority of students enter upper secondary school. In the 1994-95 school year, 100 percent of eligible students were enrolled in elementary schools; 96.5% of lower secondary school graduates entered upper secondary schools; and 52.7% entered college, university or other type of post-secondary institution (Ministry of Education, Science, and Culture, 1994).

2. Curriculum in Transition

Unlike America, Japan has a strong national system of education. Curricula for elementary, lower secondary, and upper secondary education is promulgated by the Ministry of Education, Mombusho. The Ministry of Education issues a new Standard Course of Study for each educational level about every ten years. Suggestions for curricular revisions are made by various committees that include curriculum specialists, university professors, classroom teachers, members of local boards of education, and others.

Changes in Japanese technology education programs following World War II can be divided into four eras: 1) Economic reconstruction Era, 2) High Economic Growth Era, 3) Stabilized Economic Era, and 4) International Era (Murata, 1990). Table 2 shows the socioeconomic conditions that were characteristic of each era, and upper secondary and post-secondary enrollment percentages.

2.1 Establishment of Vocational Technical Education as a Required Subject

After the end of world War II, the Japanese economy was seriously disoriented, Under the leadership of the US. Occupation Forces, various reforms in the economy and educational programs were initiated.

As shown in Table 2, during the Economic Reconstruction Era, about half of lower secondary school graduates began work immediately after graduating. At that time, vocational education was a required subject in lower secondary schools for all boys and girls, consisting of courses related to agriculture, industry, business, and home economics. The curriculum varied from school to school depending on the school's location. One of the main goals of vocational education was career education through experiential learning.

2.2 Introduction of Technology Education

Following the successful launching of the Soviet satellite "Sputnik," Japan, like many other countries around the world, tried to improve their science and technology education programs. One of the policies adopted by the Japanese government in late 1957 was the introduction of technology education, gijutsuka, as a required subject in

Table 2. Socio-Economic Development and Educational Enrollments

Era	Socio-Economic Conditions	Enrollment Percentage *	
		Upper Secondary	College/ University
Economic Reconstruction	Shortage of housing and food.	43.0% (1950) 51.5% (1955)	10.1% (1955)
High Economic Growth	Promotion of science & technology. Rapid economic growth (about 10%)	57.7% (1960) 70.7% (1965) 82.1% (1970)	10.3% (1960) 17.1% (1965) 24.0% (1970)
Stabilizes Economic	Oil crisis (1971 & 74) Economic growth slows and stabilizes (3-5%).	91.9% (1975) 94.0% (1980)	34.2% (1975) 31.9% (1980)
International & information oriented	Growth of microelectronics & service industry. Internationalization of economy.	94.1% (1985) ~~96.1%~~ 95.1 (1990) 96.5% (1994)	30.5% (1985) ~~32.2%~~ 30.6 (1990) 36.1% (1994)

* Ministry of Education, Science and Culture

all lower secondary schools beginning in 1958. With the introduction of technology education in the lower secondary school, vocational education was moved to the upper secondary level as an elective course.

The major objectives of technology education in 1958 were: 1) to help students learn basic skills through creative/productive experience, to understand modern technology, and foster fundamental attitudes for practice; 2) through experience of design and realization, to foster skills for presentation, creation, and rational attitudes for problem solving; and 3) through experience in manufacturing/operation of machines/devices, to understand the relation between technology and life and to foster attitudes for improving technology and daily life. Major content areas included design and drawing; woodworking and metal working; machin-ery; electricity; and cultivation. A total of 105 hours in each of the three grades of lower secondary school was allocated for technology education.

In 1960, the Japanese government set out to double the number of technical high schools. During this era, five-year technical colleges for the graduates of lower secondary schools were established. To res-pond to the shortage of skilled technical teachers, three-year teachers' colleges for technical education were established. These colleges were attached to Faculties of Technology at Japanese national universities. During the 1960's these colleges enrolled about 900 students each year. These policies were all related to Japan's "Doubling the National Income Program." At the beginning of this era, the Ministry of Education sent a curriculum specialist in technical education to the US. to gather information about technical-related subjects (Suzuki and Murata, 1990).

2.3 Introduction of Fundamental Subjects and Equal Opportunity in Education

Throughout the High Economic Growth Era, the percentage of Japanese students enrolled in upper secondary schools and higher education institutions continued to increase. However, the knowledge and skills needed in the workplace changed dramatically. In industry-related sectors, employers wanted workers to have greater flexibility and trainability. During this era, Ministry of Education introduced fundamental subjects to vocational technical courses and also introduced work experience activities to general courses.

In this era, issues related to equal educational opportunity in secondary education began to emerge. Until then, all male students participated in technology education classes and all female students participated in home economics classed. To provide equal educational opportunity, beginning in 1977, the Ministry of Education required all male students to take at least one home economics class and all female students to take at least one technology education class.

In upper secondary schools, students enrolled in vocational technical education were required to take fundamental subjects such as "Fundamentals of Industry," "Mathematics in Technology," and "Practice." The goal of these subjects was to improve students' fundamental knowledge and skills, as well as accommodate new teaching materials and methods (Tamura, Arai, and Murata, 1985).

2.4 Introduction of "Fundamentals of Information" into Lower Secondary School and "Independent Study Project" into Upper Secondary School.

To respond to changes in the workplace and society, the Ministry of Education initiated several changes in the late 1980's. One of the major changes was the inclusion of a new computer literacy course in technology education programs in lower secondary schools. The primary objective of the new course is to help students understand the roles and functions of computers, and develop capability for the use of computers and information. Major content areas include computers and society, computer hardware, computer software, and application of computer software.

Although the new computer literacy course is not one of the four required coursed (woodworking, electronics, home life, and food), it is one of the most popular elective courses. According to a study by the Ministry of Education (1995) 95% of all students want to take the new computer literacy course.

In the upper secondary school level, the Ministry of Education revised technical courses to encourage the development of basic skills and flexibility. In general subjects, the Ministry of Education encouraged the use of computers in science and mathematics. All vocational students are required to take a new information technology subject related to their major course, such as agricultural information processing and home economics information processing. One of the most significant revisions in upper secondary technical courses is the introduction of integrated problem solving courses, such as "mechatronics," applied mechatronics," and independent/assignment project study.

The primary objective of the new mechatronics course is to promote the understanding of fundamental knowledge and skills related to mechatronics (a combination of mechanics and electronics). Major content areas include basic machines and devices, sensors, A/D conversion, logic circuits, actuators, mechanics, and power transmission devices.

In general, there has been a movement toward a broader view of technology education and vocational education in Japan. However, a broader and less "subject-specific" approach can result in a relatively shallow educational experience. The primary objective of independent project study is for students to deepen and integrate knowledge and skills through problem solving and industrial projects. Major content areas include design, manufacture, research, experimentation, the study of workplace practice, and acquisition of profess ional/vocational certificates. Examples of projects include the design and manufacture of robots and remote control models (Murata, 1990).

3. Technology Education Teaching Methods

From the beginnings of technology education in Japan, the primary teaching methodology was experiential, based on the project method. Technology education classes in Japan are typically organized into lecture and practice classes. Practice classes (laboratory work) usually have half the number of students of lecture classes 2. More recently, new types of project activities have been introduced that attempt to integrate different technical areas and lecture content.

4. Support for Technology Education

4.1 Facilities and Equipment Support

The Vocational Education Promotion Law was enacted in 1951. As a result the national government, through the Ministry of education, was obligated to promote vocational technical education and encourage local governments to support facilities for vocational technical education. After the development of each Standard Curriculum, the Ministry of Education promulgated technology education and vocational technical education equipment standards. The national government provided subsidies to upper secondary schools that amount to approximately one third of the budget for vocational technical education facilities and equipment.

4.2 Initial and In-Service Teacher training

Initial teacher training for technology education and vocational technical education primarily occurs in the Engineering Colleges or technical education departments of national universities. Because of rapid changes in technology it is often necessary for technology education and vocational technical education teachers to be retrained. After each major curriculum revision, the Ministry of Education planned and implemented in-service training programs. A good example is the major in-service effort to prepare the approximately 16,000 Japanese technology education teachers to teach the new course on computer literacy. In the first stage of the in-service program, about 160 technology teachers received two weeks of full-time in -service training. Over a three-year period, a total of 480 such "lead teachers" received similar training. In addition to the two weeks of intensive training, these teachers assume personal responsibility for self-study about computers. Each newly retrained teacher returned to their district and began training other technology teachers in their district. In-service training at the district level continued for four years (1988 through 1992) providing in-service training to all technology education teachers in Japan (Stern and Matsuda, 1988).

4.3 Educational Centers for Technology Education

Every one of the 47 prefectures in Japan has an education center that includes a department of technology/industry-related education (including information technology). Some of the large prefectures have independent Centers for information technology or technical education. These educational institutions serve several functions including teacher retraining, development of teaching materials, and research on educational methods. In order to use prefectural educational budgets effectively, educational centers are equipped with expensive facilities such as large scale computer systems and machining centers.

4.4 Textbook Examination and Subsidies for Compulsory School Textbooks

All textbooks used in compulsory schools and most upper secondary schools are compiled and published by private publishing companies, and subject to approval by the Ministry of Education. All compulsory school textbooks, including technology education textbooks, are provided to students at no cost.

5. Problems Facing Technology Education in Japan

The following are four major challenges facing technology education in Japan. How well Japan is able to meet these challenges will determine the nature and effectiveness of technology education in the future.

5.1 Entrance Examination Pressure

Highly competitive entrance examinations are an important aspect of education in Japan. Especially important are the university entrance examinations which determine which students will be accepted at prestigious Japanese universities. Since admission to prestigious universities will result in various lifelong advantages, parents encourage their children to begin preparing for entrance examinations at an early age. The national university examinations cover five major areas: mathematics, Japanese, English, natural science, and the humanities. The entrance examination does not include content from technology education, home economics, fine arts, or health education. As a result, Japanese parents tend to regard these subjects as subordinate to subjects that are included in the entrance examinations.

5.2 Difficulty of Curriculum Change

The intervals between major curriculum change are too long to reflect changes in technology and in the workplace. This is an especially important challenge for technology education, since the content of technology education is closely related to the world of technology and the world of work.

5.3 Technology Education and Equal Opportunity in Education

Japan is beginning to experiment with a shorter work week and shorter school week. During the 1992-93 school year, many Japanese schools will not have classes on Saturdays. As a result there will be less time available for instruction. This poses an especially important challenge for technology education and home economics education. To provide equal access to boys and girls, the Ministry of Education decreased the time allocated to technology education and home economics by 50%.

5.4 Lack of Resources for Technology Education

Technology education in Japan faces a lack of resources, both financial and human. Technology education requires continuing financial investment in facilities, equipment, and materials. More importantly, it is becoming increasingly difficult to recruit good technology education teachers. Many engineering and technology graduates are recruited by companies, leaving relatively few available to work as technology education teachers.

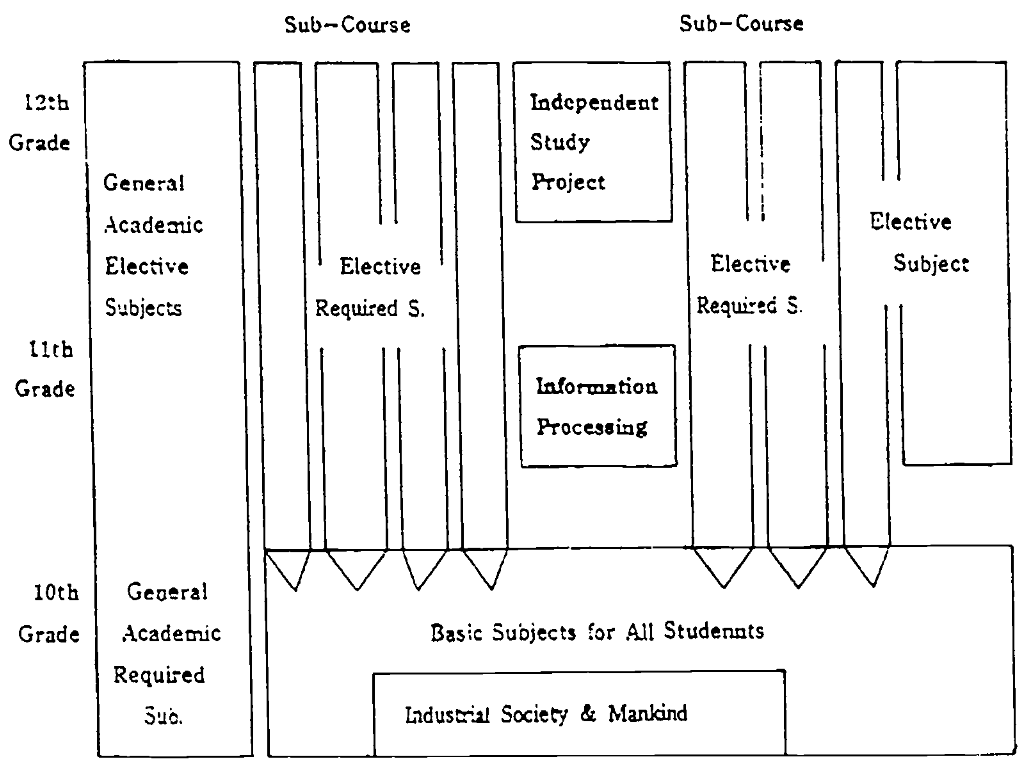
6. Newly introduced "Sougogakka [Integrated course]"

As mentioned above, entrance examination pressure changes the attitude of students and parents inducing them to pursue only entrance examination preparation with out career awareness. As a result, some general course students who fail the university entrance examinations cannot find jobs. in 1994, about 20% of graduating upper secondary school students were unemployed or changed the pathways to go to another school at the same level.

In order to improve career awareness, decision making ability, and specialized skills, MESC introduced "Sougogakka [Integrated course]", in 1994, 7 integrated course schools were established and 16 more the following year. The characteristics of the integrated course are as follow:

The integrated course was established in March 1993 as a third course, along side the general and specialized/vocational courses, the integrated course straddles the other to courses and enables students to choose they wish to study independently, according to their own interest and concerns. (MESC.)

Figure 2 shows the system of the newly introduced integrated course.



The integrated Course was established as a centerpiece in the reform of the upper secondary education system, in the integrated course students can select any sub-course/subjects according to his/her needs. However, students are asked to take some common core required subjects: "Industrial society and mankind" for career development in the 10th grade; "information processing" for computer literacy in the 11th grade; "independent study project" for self learning and problem solving ability in the 12th grade. Students are recommended to take sub-course such as the "information processing course", "industry management course", "Delivery management course", "Bio-production course", "Marine resource course", "Welfare service course", "Fine arts course", "Traditional industry course", "Environment science course", "International cooperation course", and Physical health course.

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(1) the same term, gijutsu ka, has been consistently used to describe industrial arts/technology education classes in Japanese lower secondary schools since its introduction in 1958. Gijutsu means technology and ka means subject.

(2) Average class size in Japanese schools is larger than in America. The average class size in Japan is less than 40 students per class.

日本技術教育的實施

作者：村田昭治教授

譯者：游光昭博士

壹、前言

在日本的國民小學，並未設有專為技術素養而設的課目。但仍然有一些與其相關的課目，如生活（*Seikatuka*），藝術與技藝（*Zuga-Kosaku*），科學（*Rika*），及家政（*Kateika*）等。

在初級中學則設有工藝／技術與家政（*Gijutu-kateika*）此一科目，而在高級中學階段，則無專門科目，但有生活科技（*Seikatugijutu*）單元於家政課程中。另一值得注意的是，有一整合性課程(*Sogogakka*)的開設，此課程主要在提昇生涯發展／技術素養，及整合一般及職業教育。本文主要著重在中等學校的技術教育（technology education）。

貳、日本的教育制度

近年來，日本的工業及教育實況已引起世界各國的廣泛注意。然而大家除了對日本工業及教育的興趣外，甚少關注有關日本的技術教育，本文將描述日本技術教育歷史及其現況，範圍將包括初級中學的技術教育，高級中學及其之後教育階段的職業技術教育等。

日本的教育結構主要係依據戰後美國所採用的模式。表1顯示日本的各個主要教育結構，九年的義務教育為一主要基礎，其中包括六年的小學教育，及三年的初中教育，並有近100％的日本學生完成此階段之義務教育。

在完成義務教育之後，大部分的學生進入高中就讀。根據1994-1995年的統計，小學階段有100％的就學率，96.5％的初中畢業生進入高級中學就讀，之後並有52.7％的高中生進入大學院校及其他專科學校繼續深造。

參、課程的轉變

不像美國，日本是一個中央強制的教育系統。所有的課程，包括小學、初中、高中等階段，均由文部省所公佈，文部省每十年會提出每一類課程的標準，而其中課程的修正則由課程專家、大學教授、教師、地方教育委員會、與其他相關人士相同來負責。

戰後日本的技術教育的改變可分成四個階段（1）經濟重整時期（2）高經濟成長時期（3）穩定經濟時期，及（4）國際時期。表2顯示高級中學及大專院校入學率在這四個階段中不同社經條件下的增減情況。

一、職業技術教育成為必修科目

日本在戰後，經濟發展嚴重受損，但在美國的輔助下，各種經濟及教育改革方始建立。就如同圖2所示，在經濟重整時期，有半數的初中畢業生直接進入工作世界。在此時期，所有初中的男女學生均必修職業教育，課程包括農業、工業、商業、及家政，然各校可因地區性質不同而自行調整其課程。因此，職業教育課程的目標可說是透過實際學習來達到生涯教育的目的。

二、技術教育的初始

在蘇聯成功的發射Sputnik衛星之後，日本，就如同世界其他國家一般，亦開始著手改進它的科學及技術教育課程。日本政府在1957年晚期主

要的政策即是提倡技術教育，並於1958年使其成為初級中學的必修課目，而職業教育則移往高級中學成為選修科目。

1958年的技術教育的主要目標是：（1）幫助學生從創造／製作經驗中學習基本技能、了解技術及培養工作中的基本態度，（2）從設計及現實中的經驗，培養解決問題的能力，（3）從製造／操作各種機具的經驗中，了解技術與生活的關係及培養日常生活中運用技術應有的態度。技術教育課程的內容主要包括：設計與製圖、木工與金工、機械裝置、電學等，共計105小時，並平均分配在初中三年之中。

1960年，日本政府加倍成立高級職業學校，在這時期，為初中畢業生所設立的五年制職業專科亦正式成立。並為解決職業技術教師的缺乏，三年制的職業教育師資專科學校亦於此時成立。此類專科學校附屬在日本的各國立大學中。在1960年代，這類專科學校每年約有900位學生就讀。上述的這些政策均是為配合當時政府所提倡的「國家收入加倍」計畫。而日本的文部省當時亦派遣一位職業教育的課程專家前往美國收集有關職業課程的相關資料。

三、基本課程及教育均等的引進

在高經濟成長時期，日本學生在高中及高等教育的入學率持續增加，然而，工業時代的知識及技能變化甚大。因此，雇主十分注重工人的工作變化及訓練彈性。這段時期，文部省開始引進職業技術的基本課程，並且強調工作經濟活動與一般教育的相關性。

在高經濟成長時期，中等教育的教育均等亦開始被提起。因為在此之前，男學生只學習技術教育課程，而女學生只修習家政課程。1977年，文部省便要求男學生必須選修一門家政課目，而女學生亦須選修一門技術教育課目。

在高中階段，職業技術教育的學生必須選修基本課程，如工業基礎、科技素養、及實作等。這些基本課程的目標是在改進學生的基本知識與技能，及了解新的教材與方法。

四、初中資訊基礎及高中獨立學習課程之引進

為了配合工作崗位及社會環境的變化，日本文部省於1980年代後期，開始在初中階段引進電腦素養課程，其主要目的在於幫助學生了解電腦的功能與角色，及運用電腦來發展學生的能力。此課程包括：電腦與社會、電腦硬體、電腦軟體、及電腦軟體的應用等。

雖然電腦素養課程並非四個必修科目（木工、電工、家庭生活、食品）之一，但為最熱門的選修課程。根據1995年文部省的統計，95％的學生想要選修電腦課程。

在高中階段，文部省修正了技術課程。在一般課目中，文部省鼓勵學生在科學及技術課程中使用電腦。所有的職業技術類學生亦必須修習與其專業有關的資訊技術課程，如農業資訊處理及家政資訊處理。在高中技術課程中，最主要的修正便是综合性問題解決課程的引進，如機械電子、機械電子應用、及獨立學習等課程。

新的機械電子課程主要是提昇了解機械電子的基本知識與技能。其課程內容包括機械及儀器、感應器、A／D轉化、邏輯電路、機械學、及動力傳輸等課程。

一般而言，日本已朝向廣泛的技術教育及職業教育。雖然，此舉有使教育空洞化之虞。因此，獨立學習課程便有使學生深入及整合各種知識及技能來解決問題。這類課程主要的內容包括：設計、製造、研究、實驗、工作實習、證照取得等。此類課程的例子包括有設計及製造機械人及遙控模型。

肆、技術教育的輔助

一、設施及設備的輔助

1951年的職業教育提昇法案，使得文部省有義務提倡職業技術教育，並鼓勵地方政府提供職業技術教育所需之設施。在每一個課程標準建立後，文部省便會公佈技術教育及職業技術教育的設備標準。中央政府並提供約三分之一的經費來補助設施及設備。

二、教師的在職訓練

技術教育及職業技術教育教師的在職訓練主要由各國立大學的技術教育系及工程學院來負責。由於科技變化甚大，技術教育及職業技術教育必須接受再訓練。在每次課程修正之後，文部省便會計劃如何實施教師的在職訓練。一個很好的例子是，有16000技術教育教師接受在職訓練，以便能再教授電腦素養課程。其中，在第一階段的在職訓練課程，約有160位技術教育教師接受兩週的全時訓練。三年期中，則約有180位種子教師接受相關的訓練。除了兩週全時的訓練外，這些教師並必須自行再學習有關電腦的相關知識。同時這些受過訓練的教師返回學校後，並要負責訓練其他同學區的老師，這樣的在職訓練共歷經四年（1988-1992）。

三、技術教育中心

在日本，每47個學區便有一個教育中心，這中心包括有技術／工業相關文部省門。比較大的學區更有自己的資訊技術或是技術教育中心。這些機構主要功能包括：教師的再訓練、教材發展、教學方法的研究。為求有效運用經費，這些教育中心更配有大型設備，如大型電腦系統及機械加工中心等。

四、教科書審查的補助

義務教育及大多數的高中所用之教科書係由私人出版社所編寫，並由文部省審查。所有義務教育下所用之教科書，包括技術教育所用的教科書，均由政府負責供應。

伍、日本技術教育所面對的問題

以下是四個目前日本技術教育所面臨的問題，如何來面對這些挑戰，將是決定未來技術教育實施的成效。

一、入學考試的壓力

激烈競爭的入學考試是日本教育制度下一重要課題，尤其，大學的入學考試更是決定學生進入那所學校，及其將來的生涯發展。因此，家長基本上均會鼓勵其子女提早準備入學考試所要考的課目。大學入學考試包括五個主要領域：數學、日文、英文、自然科學，及人文學。入學考試並不包含技術教育、家政、藝術、及健康教育。因此，一般的日本家長便常常忽視這類次數的科目。

二、課程改變的困難

課程修正的期間過長，使得科技及工作崗位的變化無法在課程中反映，這對技術教育影響更是深遠。因為技術教育的內容是與目前的世界技術發展及工作世界息息相關。

三、技術教育與教育均等

日本正開始實驗上課時間縮短的計劃。在1992-1993學年起，日本學生星期六不上課，這導致教學時間不足，並對技術教育及家政教育影響尤為

深遠。此外，為了使男女平等受教，文部省更降低了技術教育及家政課程各50%的時間。

四、技術教育資源的缺乏

日本的技術教育正面臨了資源的缺乏，包括財力及人力方面。技術教育需要不斷在設施、設備及材料上的投資。此外，吸引好的技術教育教師亦日漸困難。因為工程及技術相關科系的畢業生均投向企業界，只留下少許願意投入教育的工作。

陸、整合性課程的引進

如前所述，大學的入學考試改變了學生的學習態度及父母只強調入學科目的準備。因此，一些入學考試失利的學生通常無法找到合適的工作。在1994年大約有20%的高中畢業生無法受雇，或是到同級學校中繼續念書。

為了改善學生的生涯認知、決策能力、及專業技能，文部省引進整合性課程（*Sougogakka*）在1994年成立了七個設有整合性課程的學校，並在第二年度成立了16個此類學校。

整合性課程設立於1993年3月，並成為除了已一般及專業／職業課程外的第三類課程。整合性課程有別於其他兩類課程，並可提供學生可自己興趣的課程。

整合性課程已成為改革高中教育的主要工作。在整合性課程中，學生可以依自己的需求選修附屬課程。但是學生亦會被要求選修一些共同核心科目，如高一的工業社會及人類、高二的資訊處理、及高三的獨立學習課程等。同時學校會建議學生選修一些附屬課程，如資訊處理課程、工業管

理課程、生物生產課程、海洋資源課程、福利服務性課程、藝術課程、傳統工業課程、環境科學課程、國際合作課程、及經建方面等課程。

Evaluation of Technology Education: The case of Japan

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I Introduction

1 In evaluating of Technology Education, we should deliberate on both socio-economic and individual aspects. From the socio-economic view point, policy makers and educators should consider the matching between education and employment: Technical Education for Life-long Human Development in a Changing Industrial Society. Another viewpoint that concerns technology education is how students can satisfy their interests and aspiration, comprehend fundamental knowledge, and improve manual skills and problem solving skills effectively.

2 In order to evaluate technology education, the author carried statistical investigations used result of MESC (Ministry of Education, Science, and Culture) research, and introduced Japanese ways of evaluating of technology education with regard to the Course of Study, teaching schedule and teaching methodology.

II Evaluation from the socio-economic view point

3 The OECD's report on technology education discussed the following problems: (1) Breaking down barriers; the interface at the secondary level between general, vocational and technical forms; the interface between TE and higher education, the possibility of transition to a polytechnic type of higher education. (2) Integra tion of initial approach. (3) Multilevel training stream (4) Non-conflicting approach (5) Contradictory aims; individual expectation and socio-economic requirement (6) Finding balance between general and vocational technical education and factors out side TE.

4 Concerning human power development, education/training and transition from school to work have been among the key political measures among OECD member countries and Asian NMDE (Non-member Dynamic Economic e.g. four dragons) countries. The structural adjustment and globalization of economy, which often bring about unemployment on a large scale, have called for new socio-economic political measures and educational reform.

(1) *Evaluations by outside observers and actual conditions*

5 In recent years, observers in other countries have given some high evaluations to the Japanese system of education, by reason of Japanese economic development and low dropout rate in spite of high rate of students' enrollment in secondary education. However, the majority of Japanese give a low rating to the system and point out a number of problems to be solved. There is a recognition that various trends in school education have become serious problems to be dealt with immediately. These problems include juvenile delinquency; violence and mental cruelty in schools; intensified competition among pupils for entrance examinations to prestigious upper secondary schools and universities; the practice of selecting candidates for higher education almost entirely on the basis of the deviation value of students' written test; and the overall emphasis on educational background in society.

6 After compulsory education, 96.5% enter upper secondary schools, Koutogakko (1994). Of those who enter the upper secondary schools, about 2% (about 100 thousand) drop out before graduating. After upper secondary education, 36.1% enter a college/university, 16.6% enter college level courses (sennmonnkatei) in special training school (Sensyu-gakko), and 27.7% go to work. However, 6.4% cannot find jobs and 13.2% enroll in miscellaneous schools. Table 1 shows the historical trend in percentage of enrollment in each education level.

Table 1 Historical Trend in Percentage of Enrollment in each education level

	1895	1905	1915	1925	1935	1947	1955	1965	1975	1980	1985	1990	1994
Pri. Edu.	61.2	95.6	98.5	99.4	99.6	99.8	99.8	99.8	99.9	99.9	99.9	99.9	99.9
Sec. Edu.	1.1	4.3	19.9	32.3	39.7	61.7	78.0	82.7	95.3	96.5	96.0	96.1	96.5
High. Edu*	0.3	0.9	1.0	2.5	3.0	5.8	8.8	14.6	30.3	33.5	32.1	32.2	36.1

* Does not include special training schools.

7 Human power development in post war Japan has been promoted steadily. For this promotion the reform of the education system in the immediate post-war years was the starting point. It has contributed greatly to the nation's subsequent economic and social development. Japan has one of the highest literacy rates in the world. and it is common to overlook the dramatic increase in educational achievement since World War II. After the war reforms, young Japanese entered the work force with a much higher level of formal education than ever before. As a result, the current Japanese work force is a mixture of older workers with relatively lower levels of formal education and younger workers with higher levels of formal education. School education has focused on pre-employment education for young people, while leaving the development of vocational capabilities to OJT (On-the-Job Training).

(2) Students Market and New Employees Market

8 In the Japanese educational systems, there have been two main streams provided for upper secondary level students, and a dichotomy between academic orientation and vocational technical orientation in education and training. This two stream is in need of reform. Table 2 shows trends in student composition by the type of course. During the economic reconstruction era and the high economic growth era, enrollment in the vocational technical stream remained at about 40%.

Table 2 Trends in Student Composition by Type of Course.(%)

% of upper sec. sch. enrolment		general	vocational	other	
1955	79.0	59.8	40.1	0.1	
1965	92.7	59.5	40.3	0.2	
1975	95.3	63.0	36.3	0.7	
1985	96.5	72.1	27.1	0.8	
1994	96.5	74.2	24.1	1.7	

9 An entrance examination to upper secondary school in public education has been implemented by the board of education in each prefecture. Generally speaking, the selection of students depends on a written test of academic subjects and a report on the pupil's record from their lower secondary school. Regarding entrance examination to higher education institutions; in 1979, MESC introduced the National Common University Entrance Examination as the first stage selection. At the second stage, each university selects by a written test of academic subjects. Students of lower secondary schools compete to enter upper secondary schools whose students have good results on university entrance examinations. Upper secondary school students also compete to get accepted to several universities which have good reputations among large prestigious companies.

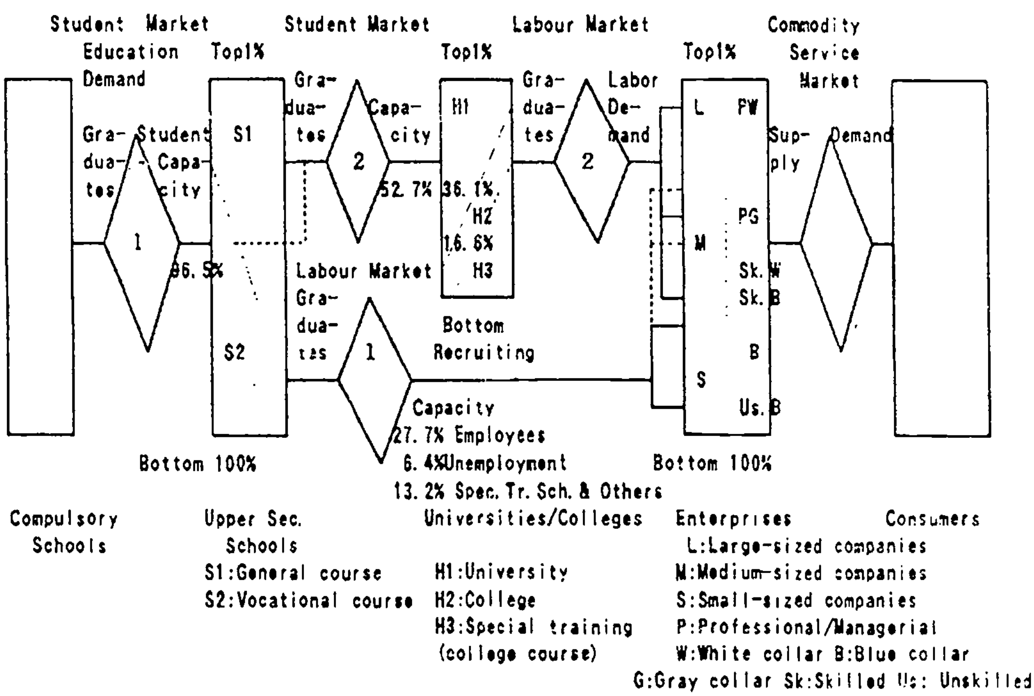
10 In Japan, the prevailing employment practice is for all companies to hire new school graduates simultaneously as of April 1 every year. In the late 1960s, this practice was institutionalized as "extended-area employment service", when the Employment Security Law was partially amended. Article 25-2 and 25-3 of the Employment Security Law prescribed cooperation between with schools and the public employment security offices. Article 33-2 of the Employment Security Law states that secondary school principals can play a role in executing the duties of the Public Employment Security Office. Recruiters of companies ask principals to recommend students as candidates for new employment. As a result, this system has been working as a nationwide new employees labor market for large-sized prestigious companies.

11 The national standardization of education has contributed greatly to the formation of a single integrated labor market for primary and secondary school graduates in Japan. Such standardization has been attained due largely to the fact that compilation of teaching subjects and contents of textbooks for primary and secondary education have been unified on a national scale by such means as the NESC's guidelines "Course of Study" and "Textbook Examination and Authorization System". Foreign observers have often recognized "Meritocratic screening" in the Japanese educational

system. The author summarized this situation in his "A tentative model of the Japanese Student Market and New Employee Market". (Figure 1)

12 Until the 1960's nearly half of the new employees were employed after completion only of lower secondary schools. After the 1970's most new employees have been graduates of upper secondary schools. New employees are composed mainly of tow groups. One group is composed of general course graduates who will not or cannot advance into higher educational institutions. The other group is composed of vocational course graduates. Regarding the curricula of vocational technical courses. the MESC has been paying attention to the reform of the learning contents and methodology in accordance with social change. However, most of the general course graduates did not learn. vocational technical subjects. Actually the number of general course graduates seeking employ- ment is larger than the number of business related course graduates of industry related course graduated seeking employment. (general: 193 thousand, business: 101 thousand, industry: 98 thousand in 1994)

Figure 1 A Tentative Model of Japanese Student Market and New Employee Market (S, Murata 1995)



13 From the view point of preparing youth for work, Japanese upper secondary education has the following problems: (1) general courses are regarded as more important, while vocational courses have been thought of as less important since the 1970s, with the result that vocational education has not been sufficiently strengthened; (2) upper secondary school education has been strongly oriented toward the preparation of students for entrance into higher educational institutions (universities/colleges). The third universal and self selective "Integrated Course (sougougakka)" was established in 1994 for the purpose of the compensating for VOTEC (Vocational Technical Education) illiteracy in general course students and enhancing Parity of Esteem between General and Vocational Education. This new type of course included not only general courses were introduced in the 1980s, such as (1) "Work experience activities" including explorative experiences and observation of work places. (2) "Interfacing vocational technical courses", and (3) "Reforming the entrance examination system" for universities.

Table 3 Pathways of upper secondary school graduates by course

	Total	General	Agricul.	Industry.	Business.	Fishery.	Home Ec.	Nursing.	Others
University	36.1	43.9	6.5	7.4	12.3	8.8	16.3	35.4	59.3
Employment	26.9	15.6	67.9	70.5	59.7	76.5	50.3	14.8	9.5
Special Train.	30.5	33.7	21.2	18.0	21.9	11.3	24.6	47.8	23.7
Others	6.5	6.7	4.4	4.1	6.1	3.4	8.8	2.0	7.5
Total number	1,658,949.	1,237,321.	44,120.	139,476.	168,510.	4,372.	35,882.	7,398.	21,912.
%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 4 Occupational Distribution of Upper Secondary School Graduates by Course

	1990			1994		
Division	Total	General	Vocational	Total	General	Vocational
Total (actual number)	622,330	291,946	330,384	459,280	200,292	258,988
Percentage	100%	100%	100%	100%	100%	100%
Professional & Technical	4.1	2.0	6.1	4.5	2.5%	6.5
Clerical Work	28.2	29.2	27.3	21.2 -	20.0	22.1
Sales Work	17.0	20.8	13.7	16.5	20.4	13.4
Service Work	11.3	13.9	8.9	14.9 +	18.6	12.0
Security Work	2.1	2.6	1.6	2.6	3.4	1.9
Transport & Communication	1.7	2.0	1.4	2.4	2.9	1.9
Production Process Work	34.0	27.6	39.6	35.9 +	30.0	40.4
Others	1.2	1.9	1.4	2.0	2.2	1.8

(3) Improving the attractiveness of VOTEC

14 Concerning improving the attractiveness of VOTEC, education systems should keep the pathways open to advanced college level courses for vocational course graduates (senkouka): and higher institutions from secondary vocational courses, (For example, the admission systems of university could be based on the recommendations of secondary school's principal (suisen-nyugaku), and the transition from school to work could be left open ended. These measures are indispensable to the improvement of the attractiveness of VOTEC. The government and local board of education improve the attractiveness of Vocational Technical Education; introduced the following measures to

a. Improve facilities and equipment by government subsidization.

b. Retraining of teacters/instructors and invitation of experienced teaching staff from industries (gaibu kousi).

c. For image change from, changing the name of the school "Vocational High School" (syokugyou-koukou) to "Specialized High School" (sennmonn-koukou).

d. Encouragement of students to get vocational certifications.

e. Emphasis on career guidance in lower secondary school such as one day schooling experience (taikenn-nyugaku) in upper secondary vocational schools / integrated course.

16 In order to have well educated / trained, polyvalent / multi - skilled and flexible workers, we have to deliberate contents and methodology in VOTEC. What are the common core contents, common issues and issues specific to each member country in VOTEC? How should the methodology in VOTEC be improved?

17 In recent years, in line with the progress of technological innovation centering on the electronics sector, there has been rapid growth in Knowledge-intensive sectors with in Japan's industrial structure. The service business sectors have also been under

going continued expansion, whereas the influence of the service economy has also been on increasing in the structure of worker's employment and consumer spending, there by prompting trend toward a soft oriented the national economy. Above all, Japan becomes an advanced information society, remarkable progress has been made in the information processing and telecommunications sectors. As a result of this progress, many smaller and lower -priced office instruments, such as office computers and work processors, and industrial robots have been successfully introduced into offices and factories, there by facilitating the trend toward office automation and factory automation. The advancement of research and development of new materials and biotechnology the new frontier technologies, are exerting an enormous impact on the real industry and economy.

(4) Systems of Education Reform and evaluation

18 In Japan, there are several councils for educational reform; the Central Council of Education deliberates general planning and central themes of Japanese education; the Council of Curricula discusses curriculum in primary and secondary schools; the Council of Educator Training discusses teacher preparation; the Council on Industrial Education (which deliberates vocational technical education reform in response to technical and social change. The MESC consults with the Council of Curriculum on curriculum reform and receives recommendations. Concerning VOTEC, MESC also cons ults with the Council of industrial Education. In line with the recommendation of the Council of Industrial Education, MESC has established several project teams and de liberated teaching contents and methodology, and has also designed concrete programs. About every 10 years, MESC reforms the curricula of the primary and secondary levels.

19 MESC investigated employers' attitude concerning secondary school graduates and the Council of industry Education deliberated on the reform of industrial technical curricula. Table 5 shows employers' expectation for secondary school graduates. The

employers' expectations are professional/specialized knowledge, skills and work attitude.

Table 5 Employers' attitudes to graduates of high schools (1994.)
(Technical High School)

Q. What was main reason for recruiting from THS ?	male	female
1 Expected specialist knowledge and skills	79.5%	52.0%
2 Expected that THS graduates would have excellent attitudes, in terms of willingness to work in personal relationship	6.3	20.9
3 The fact that recruits were THS graduates was not a positive reason	9.2	14.2
4 Other	3.2	7.0
No answer	1.8	6.0

Q. What level graduates does your company want to employ ?	
1 University graduated specialists	43.0%
2 Technical High School (THS) garduated practical technician	35.0
3 Technical College graduated middle class technician	13.4
4 Others	5.2
No answer	3.3

Q. In the event that your establishment recuruits high school graduates in future, which, between THS graduates General High School (GHS) graduates, would you prefer?

	male	female
THS graduates	65.2%	8.8%
GHS graduates	3.4	20.7
Either	21.4	31.2
Other	8.0	11.7
No answer	2.1	27.6

Q If THS graduates would recruit in futur, what kinds of education should be stressed ?

	male	female
Specialist knowledge and skills	50.1%	15.5%
Liberal arts such as language, math.	5.2	5.1
Better attitudes to work	33.4	27.2
Other	2.7	4.4
No answer	8.6	47.8

Q If advanced 2 year course for THS graduates would establish, does your company want to employ ?

	male		female	
Positively to recruit	15.4	68.4%	4.7%	33.7%
If possible to recruit	24.2		10.4	
May to recruit	28.8		18.6	
Either	23.3		23.4	
Do not recruit	3.5		7.8	
Other	4.7		35.2	

Source: MESSC 1994

(5) Technical social change and curriculum reform

20 In the last reform of VOTEC curricula in 1989, MESC emphasized problems arising from social change, especially as a result of technical innovation and expansion of service industries, and dealt with the issue of problem solving skills and flexibility. MESC introduced information. Processing related subjects for all vocational school students, independent Project Study and interdisciplinary convergent subjects such as Mechatronics (mechanics + electronics), international Economy (Business + English).

III Evaluation of the Course of Study (national standard). Revision of Contents and improvement of Methodology

(1) Evaluation by achievement test

21 In the 1960s and 1970s, MESC carried out simultaneous nation wide achievement tests. Many prefectures' board of education stressed preparation for achievement tests. The Japan Teachers' Union opposed MESC and board of education of this issues, critiquing this cramming knowledge policy.

(2) Evaluation by experimental schools

22 Beginning in the 1980s, the MESC designated experimental schools in which conditions were precisely controlled, and investigated results. The experimental schools established evaluation project teams, consisting of school teachers, teachers' consultants in board of education and college professors. The project teams make plan for evaluation from the view points of three domains: cognitive/knowledge, psychomotor skills/manipulative skills and affective/interest and attitude.

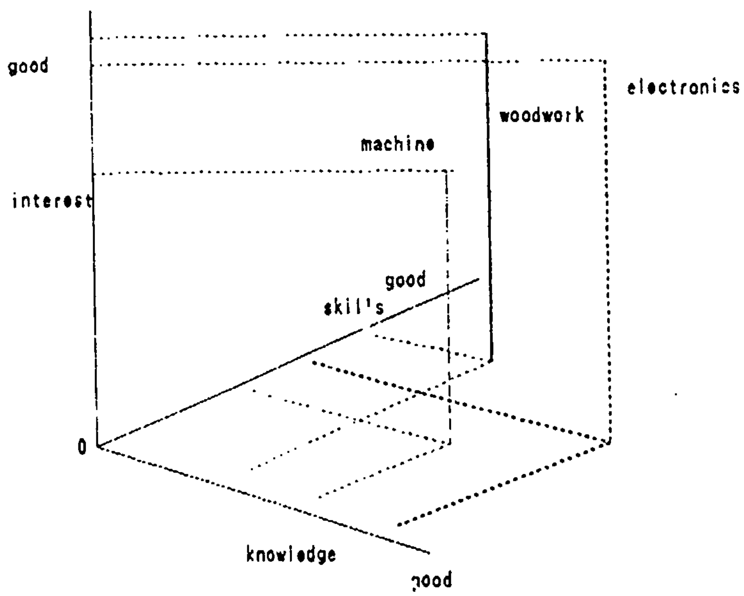
Several experimental schools carried out evaluations and sent the result of these to the MESC. The Course of Study is revised every 10 years based on recommendations of the council of Curriculum and the report of the experimental schools' evaluation of implementation. MESC analyses the reports in order to improve the contents of the Course of Study.

23 Concerning the evaluation of technology education, The author prepared a model of the "structure of capability in technology literacy of the secondary level" in 1985 as shown in the following figure 3.

Fig 3 Structure of capability in technology litera ,y.

Problem Solving Capability / Attitude		
↑	↑	↑
Comprehension ↑ Understand ↑ Taking notice	Appropriate Processing ↑ Ability to do oneself ↑ Imitation	Positive Attitude ↑ Aspiration ↑ Interest
Knowledge Cognitive Domain	Skills Psychmoter Skill Domain	Interest / Attitude Affective Domain

Figure 4 Relationship between knowledge, skill and interest in technology educatior



24 As a result of the experimental schools' evaluation, the author found several important facts on technology education: (1) psychomotor skil ls were closely related to knowledge and understanding (2) Psychomotor skills were closely related to time allocation (3) the affective domain (interets/attitude) was also closely related to understanding and manipulative skills. we reached the conclusion that it was important to select fundamental knowledge and skills, to teach/learn minimum essentials intensively, and to gradually increase and integrate contents.

25 In the 1990s, MESC suggested new viewpoints of evaluation: interest/attitude, life skills, creativity and knowledge/understanding. In 1993 MESC compiled hand book for evaluation and in 1994 MESC designated experimental schools and also carried out investigations for evaluation.

26 An investigation of an experimental school showed that creativity is closely related to fundamental knowledge in electronics classes, while in woodwork classes there is a closer relationship between creativity and fundamental skills. Table 6 shows the relationship between creativity and fundamental knowledge in electronics classes.

Table 6 The relationship between creativity and fundamental knoeledge in electronics learning.

A :excellent, B:satisfactry, C: poor

Figures in table represent numbers of students in each category

creativity / knowledge		Ability to design a circuit in order to achieve specified objectives A	B	C	Total
Types and characteristics of electric power	A	6	16	3	
	B	2	28	10	
	C	0	1	1	
cicuit composition electric power, load, switch etc	A	6	27	4	
	B	2	12	5	
	C	0	5	6	
Ability to use electric measuring instruments to diagnose problems in an circuit	A	6	28	4	
	B	2	17	8	
	C	0	0	0	
Total — Sub total	A	18 (9%)	71 (35.3%)	11 (5.5%)	49.8%
	B	6 (3%)	57 (28.3%)	23 (11.4%)	42.7%
	C	0	6 (3%)	7 (3.5%)	6.5%
Total		12.0%	66.6%	20.4%	100.0%

(3) Annual workshop on technology education as evaluation and feedback

27 An annual work shop on technology education as evaluation has been carried out in each prefecture. Each prefecture sends their representative to Tokyo. Representatives meet in Tokyo and point our problems in technology education. The MESC considers how to cope with problems. The aims of the work shops are to identify problems in implementing technology education and to find solution: the work shop has a role of feedback.

28 As an evaluation in general technology classes, the author advocates t hat (1) in the beginning of class, the teacher should carry out a simple remedial evaluation, (2) during instruction, teachers should implement a formative evaluation with checklist / observation / performance, and (3) at the end of the module / unit teachers should accumulate the results of checklist / observation / performance and project / product and carry out a summative evaluation.

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日本技術教育的評鑑

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壹、前言

技術教育的評鑑，必須考慮社經條件及個人因素。從社經背景而言，政策制定者及教育學者必須考慮教育與就業的配合：工業社會變化中人類生涯發展下的技術教育。另一考量之因素則是如何滿足學生的興趣及抱負，了解基本知識，及改進操作技能及解決問題的能力。

為了評鑑技術教育，作者將提供一些文部省所做的研究調查，並且介紹日本技術教育相關課程，教學安排、及教學方法的評鑑。

貳、從社經觀點來評鑑

在經濟合作開發組織（OECD）所發表的技術教育報告中，曾經討論到下列問題：(1)破除障礙：一般教育、職業及技術教育在中等學校的交集，技術教育及高等教育的交集，及改變成綜合技術的高等教育的可行性，(2)各種方式的整合，(3)各層級的訓練，(4)無衝突策略，(5)不同的目標：個人期望及社經要求。(6)如何在一般教育、職業技術教育、及技術教育的外在因素中取得平衡。

考量人力之發展，教育／訓練及學校到工作世界之轉換，一直為OECD國家所重視的政策。結構的調整及經濟的全球化，使得失業率持續上升，這使得教育改革及社經政策的調整成為一大課題。

一、從旁觀者及實際狀況來評鑑

近年來，外國人一直給予日本的教育制度很高的評價，因為日本一直享有高經濟成長及低的退學率。然而，日本人本身卻對其教育制度有不同的評價，並提出一些教育上的問題。大家均有面對各類教育問題的心理準備。這些問題包括：青少年犯罪、校園暴力、入學考試的競爭激烈、入學考試分數主導一切、及社會重視畢業學校的名聲等。

95%的日本學生在義務教育後，會進入高級中學就讀。而這其中約有20%在畢業之前會退學，有36.1的高中畢業生進入學院／大學就讀，16.6%的高中畢業生進入專科層級學校，另有27.7%則直接進入工作世界。另外，約有6.4%的人無法找到工作，而13.2%則進入其他學校。表1顯示各年代中不同層級學校的就學率。

戰後日本在人力發展上一直在穩定的提昇，教育的改革在戰後亦開始發展，這與日本在經濟及社會穩定發展有相當密切的關係。日本人民一直享有受教育的機會，這使得進入工作世界的人民均得有高學歷。因此，目前日本的工作市場是一種高齡低教育及低齡高教育混合而成的狀況。在日本，學校教育一直是以就業為主，而職業技能的發展則由在職訓練來負擔。

二、學生市場與就業市場

在日本的教育體制中，高級中學內一直存有一般及職業技術雙向的教育系統。表2顯示，學生在此兩種課程下之分配情況。在經濟重建及高經濟成長時期，職業技術教育的入學率一直維持約40%。

日本的每一學區均有高中入學考試。一般而言，入學的標準主要依據學術科目的筆試成績及其初中之成績。至於大學入學考試方面，在1979年，文部省引用國家一般大學入學考試作為第一階段之選擇。第二階段則

由各大學依據學術科目之測驗成績作為選擇之標準。一般而言，初級中學的學生均傾向投考有較高大學錄取率之高中，同樣地，高中學生亦努力爭取投考具有較高聲望之大學。

在日本，公司均於每年的四月一日招收新的畢業生，在1960年代後期，就業保護法修正後，25-2及25-3條更規定了學校必須與就業保護單位合作。23-2條並明示了中等學校校長必須在執行法令上扮演重要的角色。因此，雇主可以透過校長推薦的畢業生來進行選才，而這種方式亦廣為全國性大公司的一個主要選才系統。

國家教育的標準提供了初等及中等學校畢業生一個完整的整合性勞力市場結構。這個標準的建立主要是因初級及中等學校的課程及教科書內容均在文部省所定的審查規範下編寫。作者將這種市場結構情形做成如圖一〝日本學生及新受雇者市場之試驗性模式〞。

在1960年代之前，約僅有半數的受雇者完成初級中學的教育，到了1970年代，大多數的受雇者已具有高中之教育程度。這些新的受雇者可分為兩類，其中一類是具有一般課程，但無法進入大學之畢業生，另一類則是修習職業課程教育之畢業生；在職業技術課程方面，文部省一直扮演著課程改革的角色，以便配合社會之變遷。但一般課程之畢業生，則沒有學習有關職業技術課程。

事實上，一般課程之畢業生，在尋找工作機會的人數上，遠多於商業或工業相關課程之畢業生。從培養青年就業的立場及觀點來看，日本高級中學教育有如下之困難：(1)從1970年代起，一般課程比較受到重視，而職業教育課程則較受忽視。(2)高中教育一直被強調為高等教育之準備。第三類之整合型課程設立於1994年，其主要之目的就是為幫助一般課程之學生，補足其在職業教育課程之欠缺。這類新課程，除包括一般科目、職業科目，另提供藝術、傳統技藝、社會福利等相關課程。

三、職業技術教育之改進

職業技術教育之改進措施，首先必須提供職業教育畢業生較多進入大專院校之機會。例如，大學的入學審查可以依據中學校長的推薦。此外，改善職業技術教育的方式，尚有下列方式：

1. 由政府補助經費來改善設施及設備。
2. 教師的再訓練及吸引工業界有經驗的人士加入教育行列。
3. 名稱的改變，應從職業高中改成專業高中。
4. 鼓勵學生考取證照。
5. 初中應注重生涯輔導，讓初中學生有一天的機會經驗高中職的整合性課程。

為了培養具有多種技能及具有受教育及訓練的工人，職業技術教育必須深思其教學內容及方法。例如，什麼是核心課程，一般性課題，及如何改善教學方式。

近年來，由於電子科技的快速成長，日本的工業結構亦朝向以知識密集為主。另服務業的成長亦相當快速，它的影響也改變了工作就業及消費者的消費情形。除此，日本亦成為高度資訊的社會，並在資訊處理及通訊方面有長足的進展。故而許多小型及低價位的辦公儀器，如電腦、工業機器人均成功地打入公司及工廠，而形成辦公室及工廠的自動化。同時，新材料及生化科技的發展亦深深地影響了目前的工業與經濟。

四、教育改革的系統與評鑑

在日本有許多教育改革的委員會，中央教育委員會一直在規劃日本教育的一般性計畫及中心課題。其中的課程委員會主要在探討初級及中等學校的課程，教師訓練委員會則研究教師培育問題；工業教育委員會則評估在技術及社會的改變下如何改革職業技術教育。在職業技術教育的相關議

題上，文部省經常諮詢工業教育委員會，文部省並會因應工業教育委員會之建議，成立多個研究小組，針對教學內容及方法提出具體措施。

每隔十年，文部省會針對初級及中等教育的課程作適當之改革。文部省亦會調查中等學校畢業生的受雇態度，而工業教育委員會則評量工業技術課程之改革。圖五顯示，雇主對中等學校畢業生之期望，其中雇主的期望主要包含專業知識、技術、及工作態度。

五、社會改變及課程改革

在1989年的職業教育課程改革中，文部省主要的改革重點在於針對社會變化所產生之問題，例如技術改革及服務業的快速成長及問題解決能力的課程。文部省也提出了職業資訊處理等的相關課程，及獨立計畫之研究、多領域課程、及國際經濟等相關課程。

圖五　雇主對高中畢業生之態度(技術高中，1994。)

問題:什麼是雇主吸收技術高中畢業生的主要原因?

	男	女
1、期望專業知識與技能	79%	52%
2、期待技術高中畢業生有良好的態度	6.3%	20.9%
3、吸收技術高中畢業生不是一個正面的因素	9.2%	14.2%
4、其他	3.2%	7%
無作答	1.8%	6%

問題:貴公司希望聘用何等層級之畢業生?

1、大學畢業的專業人士	43%
2、技術高中畢業的技術人員	35%
3、技術專科畢業的中級技術人員	13.4%
4、其他	5.2%
無作答	3.3%

問題:未來如果聘用高中畢業生，你會選擇技術高中畢業生或一般高中畢業生?

	男	女
1、技術高中畢業生	65.2%	8.8%
2、一般高中畢業生	3.4%	20.7%
3、二者均可	21.4%	31.2%
4、其他	8.0%	11.7%
無作答	2.1%	27.6%

問題:如果你未來想要吸收技術高中畢業生，你希望他具有什麼樣的教育專長?

	男	女
1、專業知識及技能	50.1%	15.5%
2、文藝素養	5.2%	5.1%
3、良好的工作態度	33.4%	21.2%
4、其他	2.7%	4.4%
無作答	8.6%	47.8%

問題:若在技術高中之後，設立兩年的高中課程，你的公司會願望雇用這些人嗎?

	男	女
1、絕對願意	15.4%	4.7%
2、儘可能願意	24.2%	10.4%
3、可能願意	28.8%	18.6%
4、中立態度	23.3%	23.4%
不願意	3.5%	7.8%
其他	4.7%	35.2%

参、課程評鑑內容的修正及方法的改進

一、以成就測驗來評量

在1960及70年代，文部省實施全國性的成就測驗，各學區亦積極準備此種能力測驗。然而，日本教師聯盟強力反對文部省的此項措施，並批評此為填充式的教育政策。

二、實驗學校的評鑑

從1980年代起，文部省指定若干學校進行實驗，並由實驗學校成立評鑑小組。小組由學校教師、教育委員會顧問、及大學教授組成。評鑑小組所建立的評鑑標準主要是從下列三個領域著手：認知/知識，動作技能/操作技能，情意/興趣及態度。

一些實驗學校完成評鑑並將結果寄予文部省。課程每隔十年均會依據課程委員會之建議及實驗學校評鑑之結果而做適當修正。文部省並會分析研究報告之內容以作為改善內容之參考。

關於技術教育的評鑑，作者提供了1985年「中等學校技術素養之能力結構」模式（如圖三），根據實驗學校的評鑑結果，作者發現有關技術教育的重要課題:(1)動作技能與知識及了解有高度的相關。(2)動作技能與時間分配有密切關係。(3)情意與認知及操作技能亦有高度相關。因此我們認為，選擇適當的基本知識及技能、密集的教/學基本課程，及逐漸增加及整合內容等均是非常的重要的課題。

1990年代文部省建立新的評鑑觀點:興趣/態度、生活技能、創造性、及知識/認知。在1993年，文部省並發行評鑑手冊，1994年，文部省並指定若干實驗學校完成評鑑調查。

實驗學校的調查顯示創造力與電子學的基本知識有密切相關，而木工則與創造力及基礎技能有高度相關。表六顯示在電子學中，創造力與基本知識之相關性。

三、以技術教育年度研討會作為評鑑及回饋之參考

各學區每年均有技術教育研討會以作為評鑑之參考。各學區均會派代表至東京開會以探討技術教育的問題，並由文部省負責解決這些問題。研討會的目標主要在確認實施技術教育所面對的問題並尋求解答。因此，研討會通常扮演著回饋的角色。

另在一般科技教室的評鑑上，作者認為應該著重(1)教師在上課初期應實施補救評鑑，(2)在教學中，教師應實施形成性評鑑，如檢核表/觀察/表現，(3)在單元結束後，教師應收集檢核表/觀察/作業表現/成品來實施總結性評鑑。

A Study of Introduction of "Foundation of Information" and Individuality Based Instructions

[Key words: computer literacy, Individuality based learning, BPI (Brain Predominant Index), IQ (Intelligent Quotient), teaching aids/materials.]

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Abstract

In Japan, the Ministry of Education introduced "Foundation of Information" as a part of the required learning contents. Computer learning has often been the cause of dropout. concerning individuality based learning, the main issue is how to cope with dropouts in computer learning. In order to achieve "computer literacy for all" we tried to research the actual condition in computer learning. We investigated students from the viewpoint of individuality: three groups of IQ and Predominant Laterality of Brain (BPI = Brain Predominant Index) and identified a relationship between individuality and test scores in computer learning. As a result, we found that the higher IQ group and the left brain predominant group students tended to get better scores, while the lower IQ group and the right brain predominant group tended to get worse scores. The higher IQ group, and the left brain predominant group are good at theory, the lower IQ group and the right brain predominant students didn't show any interest in theory.

The lower IQ group and the right brain predominant group students didn't achieve good scores, however they were interested in practice oriented learning by the use of home-made teaching aids/materials. In order to achieve the goal of "computer literarcy for all", practice oriented instruction is the relevant way of beginners in computer learning.

1 Introduction

Now is the timeo f the information oriented society.1 Developed countries have already introduced an information related subject as the core of school education.2,3. In 1989, the Ministry of Education Science and Culture (MESC: Monbusho) revised the Course of Study (Shidoyoryo) and introduced "Foundation of Information (Johokiso)" as a required contents of "Industrial Arts and Home Making (Gijutu-kateika)" in Japan.4

Foundation of Information is composed of four main components: 1) construction and function of the computer, 2) fundamental operation of the computer and basic pro garamming, 3) use and application of the computer and 4) the roles of the computer and information in industry and daily life. This is a course of study carried out from 1993.

In the term of transition from the old course of study to the new one, the MESC has been preparing teachers and computers. During that time, Masao MURATA et al (1987-), Shoji MURATA et al (1989-) tried to research the relationship between individuality and achievement test scores of newly introduced contents concerning computer literacy. Masao Murata et al adovocated IQ-BPI battery examination improves the validity of the examination of individuality by investigating over 3000 students [5,6].

The BPI showed qualtradve aspects of individually, while the IQ showed quantllative aspects.

2 Procedure of Research

(1) After learning content: 1) roles of computer and information in industry and daily life, 2) construction and function of computer, 3) fundamental operation of computer and basic progaramming, 4) use/application of computer such as word processor, graphics and auto-machine control etc, (2) we investigated students' test scores in computer learning, and also (3) investigated the relationship between the results of required subjects such as English, mathematics, science, Japanese and so

on, as well as test scores in computer learning (4) We examined IQ and BPI (hrain predominant, index) of students and (5) investigated the relationship between the differences of the three groups of IQ and test scores in computer learning, and also (6) investigated the relationship between the difference between the three groups by BPI and test scores in computer learning, and furthermore, (7) We compared results of using home-made teaching aids and not using home-made teaching aids. Finally, we tried to identify the relationship between test scores in computer learning and individuality.

Table 1 Grouping of IQ (SD)

Higher group	higher than 61
Middle group	51 - 60
Lower group	lower than 50

Table 2 Grouping of BPI

Left brain predominant	lower than 4.4
Both brain	4.5 - 5.4
Right brain predominant	higher than 5.5

3 Result of Investigation and Discussion

(1) There is a relationship between the result of required subjects and test scores in computer learning in lower secondary schools. Table 3 shows the relationship between results of subjects and test scores in computer learning. Through investigation, we found that the result of technology, science and matematics is highly related to the test scores in computer learning. In order to idntify the significance, authors examined by T - score and x^2 Chi-square and we found a strong relationship between technology, science and mathematics and computer learning.

(2) The relationship between IQ and test scores in computer learning: Fig 1 shows a relationship between IQ and test scores in computer learning. The lower IQ group is largely behind the higher and middle IQ groups in both the understanding mechanism and the construction of computer and fundamental programming.

Table 3 Relationship between result of other subjects and test scores in computer leaming.

	higher IQ group		middle IQ group		T-score	x^2
	av. score	SD	av. score	SD		Chi-square
Japanese	71.8	11.3	69.1	14.4	0.805	9.3
Social St.	77.8	15.7	68.5	20.3	+1.978	14.5
Mathematics	72.9	14.8	55.3	26.3	*3.214	+19.4
Science	88.9	7.0	80.0	9.7	*4.069	*23.30
English	93.0	8.8	77.8	22.1	*3.532	13.8
Technology	83.0	13.6	66.2	11.7	*5.197	*70.30

level of significance + 0.05 * 0.01

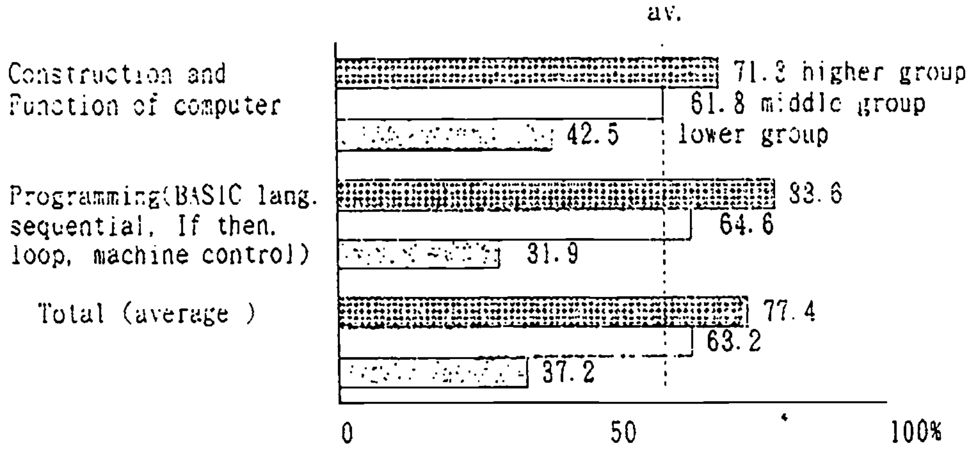

Fig 1 Relationship between IQ and test scores in computer learning

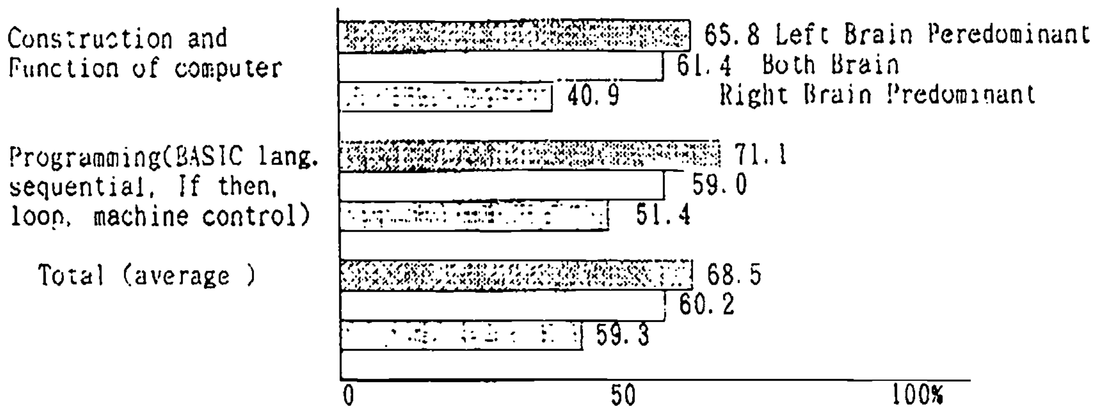

Fig 2 Relationship between BIP and test scores in computer learning

(3) Relationship between the BPI and test score in computer learning: Fig 2 shows a relationship between the BPI and test scores in computer learning. The left brain predominant group students got better results, while the lower IQ group and the right brain predominant group got a lesser scores. Comparing the relatlionship between IQ and test scores in computer learning, we found no significant difference between the left brain predominant group and both brain group except that the right brain is the predominant group.

(4) Relationship between the result of subjects: mathematics, science, and technology and test scores in computer learning.

1) Result of mathematics and test scores of computer learning:Fig 3 and Fig 4 shows a relationship between the result of mathetmatics and science, and test scores in computer learning. The three student groups were divided by the result of the subjects largely differing in test scores in computer learning.

2) Result of Science and test scores in computer learning

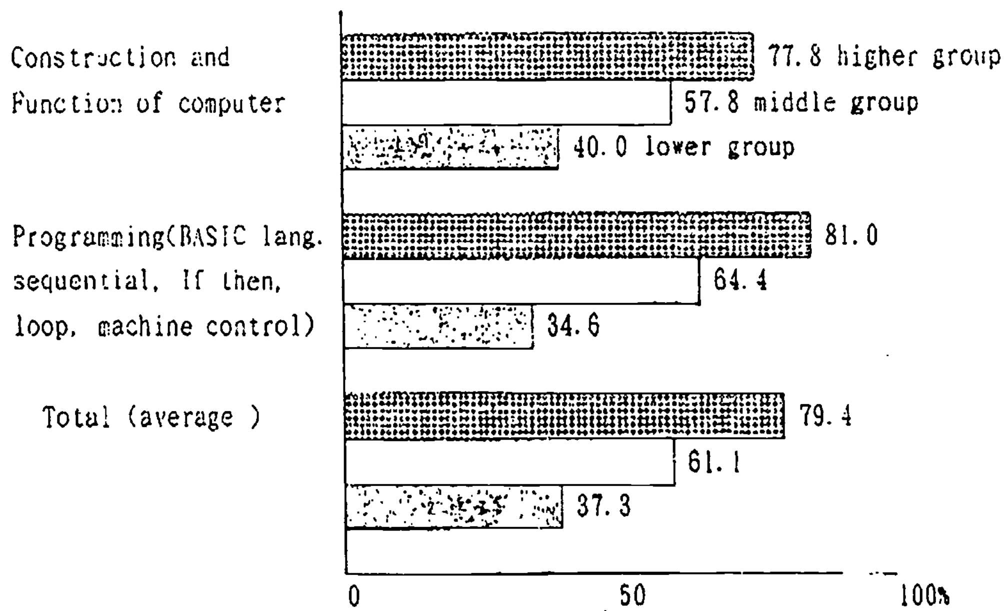

Fig 3 Relationship between the results of mathematics and test scores in computer learning

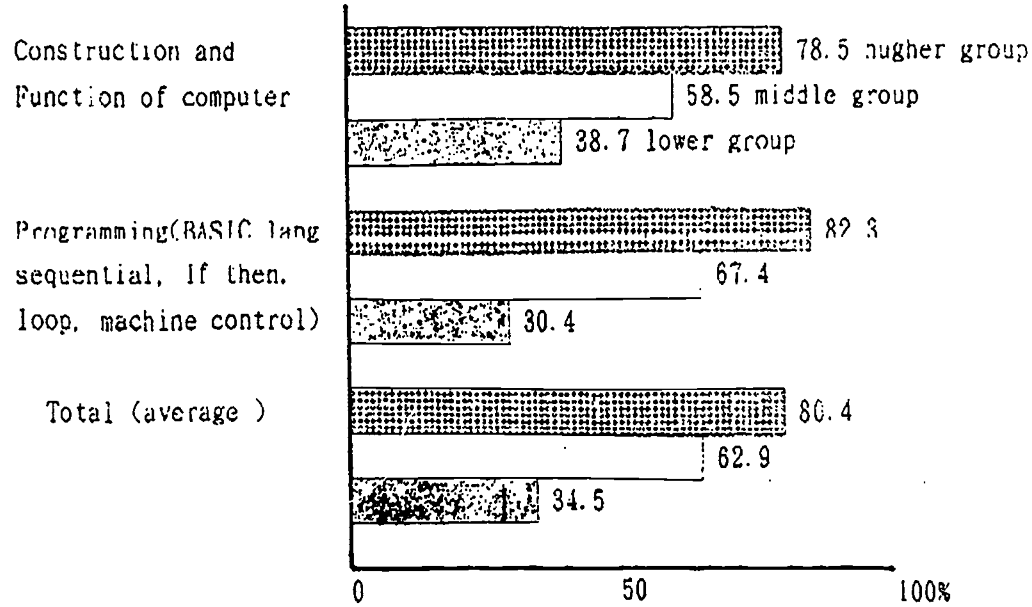

Fig 4 Relationship between the results of science and test scores in computer learning

(5) Relationship between test scores and teaching aids used in computer learningg: As mentioned above, the lower IQ group students and the right brain predominant group students got worse test score in computer learning. In order to cope with this problem, teachers developed teaching aids/materials. Fig 5 shows a relationship between using teching aids and test scores in computer learning. Teaching aids group got better test score in almost all contents. Teaching aids/materials are particularly effective concerning theoritical contents in computer learning for beginners.

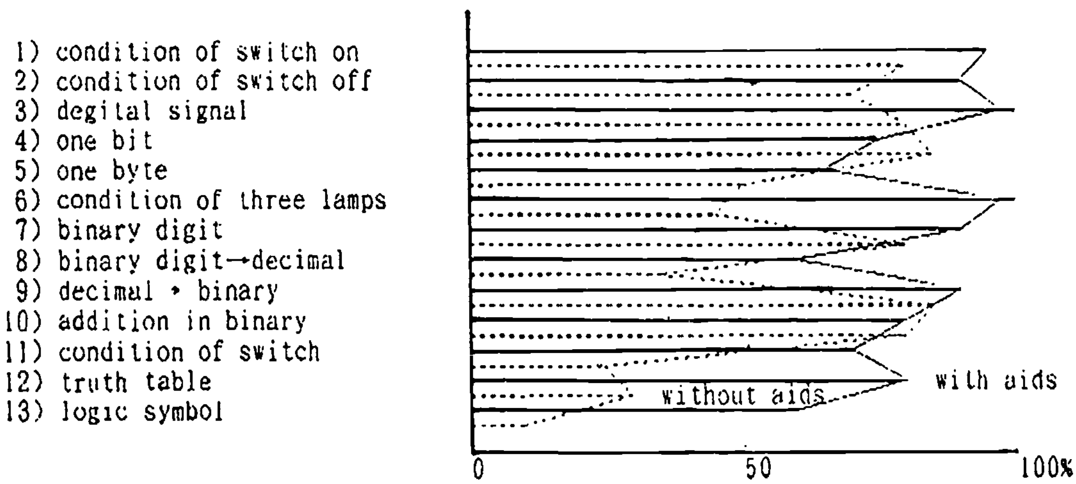

Fig 5 Relationship between using teaching aids using the test scores in computer learning

4 Conclusion

In order to achieve the goal of "computer literacy for all", we investigated a relationship between test scores and individuality: result of required subjects, IQ and PBI. The result of required subjects: technology, science and mathematics are strongly related with test scores in computer learning. The higher IQ group students and the left brain predominant group students got better test scores in computer learning. The lower IQ and the right brain predominant group got worse test score. The right brain predominant group students found of practice, practice oriented instruction togather with teaching aids is most effective in computer learning.

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