Cross Border:
International Cooperation in Industrial Technology Education

AICHI UNIVERSITY OF EDUCATION
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This monograph is a report of the Second International Symposium on Educational Cooperation for “Industrial Technology Education” held at Aichi, Japan, July 4-6, 2008.

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Preface

The informatization and internationalization of society have been accelerated more than ever on a global scale. Accordingly, our living conditions and social environment are changing drastically. At the same time, it is claimed all the more that all people of all countries should live a more prosperous and stable life. In order to realize this vision, I believe that it is indispensable to develop and establish a society supported by industrial technology in each country. The advancement of industrial technology education is a crucial condition as it is the basis of this type of society.

In pursuit of the enhancement of industrial technology education worldwide, since 1999, Aichi University of Education (AUE) has hosted the Group Training Course in “Industrial Technology Education” held by Japan International Cooperation Agency (JICA) under the supervision of JICA Chubu International Center. This year is the tenth and I regard it as a milestone of our commitment. During this decade, placing special emphasis on this Group Training Course in “Industrial Technology Education,” AUE has also organized in “Engineering Education,” “Curriculum Development” and “School Education Improvement.”

On the other hand, 2007 the International Division of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) commissioned us with the International Cooperation Initiative Project in order to transmit these training outcomes around the world. The project title is “Model Creation of Core-curriculum Sharing System for Supporting the Industrial Technology Education in Developing Countries.” In this project, we integrate all the textbooks and materials which we use for the training courses and study how to provide them in the form of publications, disks and electronic information.

To commemorate this tenth consecutive year, we decided to hold this International Symposium on Educational Cooperation with a view to coordinate our experience and knowledge up to the present. We organized the
1st International Symposium in 2003 and this year, common critical issues concerning “human resources development for making things” of each country are to be presented. The Symposium’s goal is to share such information among participants through mutual understanding and to study practical solutions and achievements of other countries introduced from various standpoints, so that these shared experiences can contribute to solving the problems in industrial technology education of the respective countries.

Now let me explain the logo of the Symposium poster. The central two leaves portray the “T” of technology and at the same time this shape represents a traditional craft called “Taketonbo,” a helicopter-like toy made of bamboo, as well as the “Moebius Loop” which highlights the infinity of technology that exploits a path to the future. As education encourages growth, the two leaves indicate an image of “growing.” Moreover, green and blue are chosen as base colors since industrial technology is closely linked with the environment. This design implies great expectations and possibilities lying in industrial technology education of coming generations. I truly hope that this Symposium has borne fruitful results for the future of industrial technology education in the world.

Finally, my deepest gratitude goes to JICA, MEXT, Boards of Education of the respective local authorities, Kariya City, the companies that supported and cooperated with this event, as well as all participants who joined in this Symposium for their valuable contributions.

March 15, 2009

Hidetoshi Miyakawa, General Chair of Symposium

The Second International Symposium on Educational Cooperation for Industrial Technology Education
Aichi University of Education (AUE) is publishing this monograph to increase the availability of area and global information on industrial technology education. All information focuses on advancing international understanding and cooperation in the field of industrial technology education. The papers collected in this monograph are selected from the manuscripts presented at the second international symposium sponsored by the Japan International Cooperation Agency (JICA) and AUE, held in July 2008. The preface, written by Dr. Hidetoshi Miyakawa, points out the efforts of both JICA and AUE as well as some important background surrounding the Symposium.

This monograph is organized around three main themes. Chapter I presents the diverse contexts and content that reflect the multiple approaches to industrial technology education. Chapter II provides readers with an opportunity to understand industrial technology education through the telescope or microscope of international technology educators. Chapter III emphasizes the needs, models and variables for international cooperation.

Cooperation makes everything easier and everyone feel warm inside. It is our sincere hope that this monograph will assist with the promotion of international cooperation in industrial technology education.

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Considerations on Selecting Content for Technology Education

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1. Introduction

In March 2008 in the Council on Technology Teacher Education (CTTE) began a discussion on renaming Technology Education with Engineering or Engineering Design - whereas a big part of the public still has Industrial Arts in mind. In an e-mail to the CTTE listserv, Franzie Loepp wrote:

“As for a name, what we (CTTE Listservers) call ourselves is important to us but what others call us is the name that will prevail (for decades). Do you suppose we can get our society to refer to our programs as “engineering shop”? At the beginning of the semester when I went to observe a student teacher I was told I would find Mr. (Cooperating Teacher) in the “shop”. Since I have lived much of our history I knew what she meant! (Fortunately I found Mr. . . . in an up-to-date lab teaching a multi-disciplinary program - he had up engineering in it’s title.)”

This is partly due to the perception of Technology as “making things”, but underlying is also the issue of content of Technology Education.

Activities and methods of technology change only very little in the course of time - they are time invariant, while technology changes. So they are subject matter with specific value. Technology education has to ensure the usage of technological activities and technological methods. Some of the methods are methods to make a process (or an artifact) understandable. So they are pedagogical per se. Good examples for these sorts of methods are the
simplifying/systematizing methods. Abstract and symbolic representation of systems, subsystems and their combinations is a tool for many engineers today, to communicate with colleagues or for decision making.

Technology is solving problems. Technology is as manifold as the problems to solve. There are many ways of structuring technology by the disciplines of technological sciences. But there are reasons, not to use this structure for selecting the content of technology education. Technological sciences are subject to an ongoing process of differentiation and integration. Fields for selecting content are:

- **Technological processes**,  
- **Technological systems**,  
- **The design process (generating technological systems, life cycle management)**,  
- **Fields of action in technology**

The Association of German Engineers (Verein Deutscher Ingenieure, VDI) has developed a set of guidelines for engineering. These guidelines are part of the German standardization program conducted by the German Institute of Standardization (Deutsches Institut für Normung, DIN). There are guidelines which refer to the design process and the technological process. Since with the complexity of industrial product the design process is changing, the design guidelines are kept up to date to enable the engineers to cope with their mission.

2. **Technological processes**

In technological artefacts, processes are running, which determine the function. Normally matter, energy, and information are processed. The processes can be described as system, possibly split into subsystems. Subsystems communicate over interfaces. These interfaces have to be defined in the design process in order to be able to design in division of labor.
Simple actions like transport, storage can be combines in a technological process to very complex interdependent processes. Every process can be described as processing material, energy, and information with auxiliary means, procedures, and human activity. Standard DIN 66201 defines the technological process. Important for us technology educators, there are several possibilities to communicate the ongoing processes. These are:

- Arrows represent the information or material flow
- Bundles of connections are shown as double lines with arrow

and the phase model representation (Fig. 5).
- Mixture of flowdiagram and information/material-oriented representation
3. Technological systems

Technological processes can be described as systems, possibly split into subsystems. Subsystems communicate over interfaces. These interfaces have to be defined in the design process in order to be able to design in division of labour. Analyzing technological systems we can see, that the behavior depends on the way of feedback in the system - positive or negative and/or with a delay. The feedback makes the system work properly or oscillate or destroy itself. With the knowledge about systems gained in technology education, student can analyze processes in nature and society.

Content of technological systems is the vocabulary of control technology:

**Control in a closed loop:** Controlling in this case means to record continually one or more quantities of a process - controlled variable - , comparing them with the command control input and influencing the manipulated variable. The process to be controlled is called controlled member. (v. Figure 7)

**Control without feedback:** As opposed to control in a closed loop, this is an open (not feedback) process. One or more input quantities or manipulating quantities influence the output quantities. These don’t have any repercussion on the input quantity.

**Goal function:** To construct a control, a goal has to be defined in order to dimension the control system after having estimated the expected disturbing variables.

**Input quantity:** The measured variables of the control system are the input quantity for the process computer.

**Manipulating variable:** The manipulating variable indicates a quantity which influences the process. The manipulating variable is adjusted by a correcting
element (e.g. transistor, valve, ).

**Measuring:** Measuring is the establishment of an physical quantity according to number and unit. In most measurements, carried out in the course of a control nowadays, the quantity is recorded by a sensor and transformed into an electrical quantity.

**Oscillation:** Shifts of phases can arise between control order and controlled system, when the control circuit contains delay elements or elements of inertia.

**Output quantity:** On the basis of input information, which is connected according to certain rules (program), a process computer generates output information in order to control processes.

**Stability:** The main problem in control technology is to ensure the stability of systems. Stability is only possible if any disturbance variables and the system’s response to these are known. Otherwise the system is in danger of succumbing to oscillation.

All these properties of a technological system with control loops can be trained with op-amps. Nowadays, most of electronics works digital, but some parts of analogue electronics are still indispensable. Op-amps can be modelled as a program in microcontrollers, but first hand experience requires “real” op-amps.

The challenge for technology education is to make the pupils as competent as possible, so they can follow and participate in this discussion. Technology education can in the first instance encourage a new way of thinking, different from the ones we learned in school so far. (VESTER, p. 7) In the course of these considerations, even the discussion about the so called “technical thinking” could resurface on a different level. In former educational concepts the “thinking in context” was encouraged, whereas, according to the present day knowledge the “thinking in dynamic context” could become an aim. An extensive understanding about control engineering also makes it possible to embrace and better understand individual pieces of knowledge from technology education.

SIMON (p. 52) reports about experiments, in which people had to tackle the task of improving, living conditions in a fictitious African country. They were told to include social, economic, ecologic and technical facts into their
decisions. Only a few of these persons actually reached an improvement. Nevertheless SIMON’s analysis of their mistakes is however useful material for school use. The principal mistakes were:

- lack of simple “technical knowledge” (for example estimation of dimension of increase in an exponential function)
- to think in a simple cause-effect-relationship without any attention to side effects
- concentration on single facts, disregarding the more complex connections
- no fundamental revision of the steps proposed.

The reasons for the mistakes can now be converted into the positive and serve as learning aims in class. Thus the pupils are supposed to learn:

- to estimate qualitative relationship, depending on whether the basis is a linear or exponential function
- to observe repercussions and side effects when analyzing cause-effect-relationships
- to inform themselves about more complex relations and not just simple facts
- to revise their own steps known to be problematic.

These aims, that emerged are of a more general nature and as such they are not just valid for teaching technology. There have been attempts to show the real industrialized world as a combination of different control loops. Detzer is one of the experts to use this approach (v. Fig. 8) as a base for ecological thinking.

![Diagram](image.png)

**Fig. 8** The Industrialized World Shown as an Interaction of Subsystems
4. The Design Process (Generating Technological Systems, Life Cycle Management)

Technology is generated in processes, which are systematized and refined in the course of development. Theses processes are comprehended as “design process” and play a significant role in the education of engineers. The design process includes all steps from determining needs to putting out of operation and recycling. The Association of German Engineers has published guidelines, in which the design process is formalized to enable the integration of computers.

As a result of the changes in the requirements within the design process, an increasing degree of interlinking of the development processes and the increasing possibilities to handle projects across multiple locations are vital. The term “mechatronics” covers an open interchange between mechanical and electrical engineering. The resulting seamless handing over of the data in all the life cycles of the plant, unit or machine often is covered across all technical areas by integrative software solutions.

Mechatronic systems are gradually replacing mechanical systems. Several reasons are behind that trend.

- Decreasing price and increasing functionality of digital processing units and electronic components.
- New, additional functionalities, due to the use of electronics.
- Mechatronic systems are lighter and simpler, as they replace complex mechanics that had to control or steer a system before.
Mechatronic systems can be easily adjusted by changing the software.
The possibility to generate independent modules reduces the complexity of extensive systems.
User interfaces enable the direct supervision and interaction with the system by a supervisor.

As the mechatronic products integrate functionalities, modules and elements of several disciplines, engineers of these disciplines have to cooperate close. This requires:

- Communication between formerly separated departments in companies.
- Interdisciplinary education of engineers.
- Integrating of formerly separated development processes.
- Methods to handle the increasing complexity.

The development process of a mechatronic system is characterized by a much higher complexity, more parameters and a larger quantity of data compared to the classic discipline-separated development process.

It requires an extended concept of complexity with five main dimensions:

- Numerical complexity
- Relational/structural complexity
- Variation complexity
- Disciplinary complexity
- Organisational complexity

Mechatronic products tend to be complex in all of those five dimensions. They involve a large number of elements that are related in numerous ways. The variation complexity can be high if the product is a sub-module of a versatile product. As an example an anti-lock braking system can be used in a large number of different cars, if varied according to the applied car.

The disciplinary complexity of mechatronic developments is obviously high, due to the involvement of several disciplines. The organizational complexity can be high depending on the distribution of the work.

The VDI-Guideline 2206: “Design methodology for mechatronic systems”, promotes a process model for design, the V-Model. (Figure 11) The V-model starts with the requirements for the product. During the system design the crossdomain principle solution is determined. Following this the disciplines work on the solution of their domain and create as domain-specific design. At the integration stage the results from the domains are integrated, then the results are verified and validated. The loop can be repeated several times, for
example to create a laboratory sample, a prototype, a pre-series product and then the end-user product. To support the development process, computer based modeling and model analysis can be made to map and investigate the system properties. The process model is used to manage teams of engineers resident in different disciplines.

Although the described process models seem to be quite diverse, with different names for particular steps and different general shapes, the underlying principle is similar: the development is divided into an analysis phase and a synthesis phase (v. Fig. 12). The idea is to analyze a problem first, so that it is understood as comprehensively as possible. The problem is described in a neutral and functional way that does not imply solutions. In the synthesis phase solutions are investigated and combined. This ensures the finding of new and innovative solutions that are not affected by subliminal restrictions. The interplay between synthesis and analysis does not only occur on the macro scale over the complete development process, but also when solving every subtask.

**Level I**

System and subsystem hierarchy, subsystem general interactions are defined. The main functionality and system states are indicated.

**Level II**

Subsystems are opened and defined in general ‘black box’ components. The
parameters of subsystems are initiated. Subsystem inner activities are
distinguished.
Level III
Component parameters are defined and cross diagram relationships established.
The allocation diagram can be used to define these relations. System and
subsystem behavior is opened as detail as needed. The parameters of model and
component are defined according to selected simulation model need.

5. Fields of Technological Action

All these systematics/structures can not assure that technological content
important for a certain historical period is dealt with. In many approaches to
technology education there is a listing of areas in which technology plays an
important role and therefore are to be considered for a well balanced
representation of technological content. (“Fields of action” in Germany,
“systems of technology” in the US)

These “activity fields” and possible content are:

5.1 Work and Production

- Materials: wood, metal, plastics, and
  ceramics as well as their main properties
  and their applicability for manufacturing.
- The problems of procuring and processing
  raw material under economic and ecological
  aspects.
- The impacts of pollution in industrialized
  and non-industrialized countries and
  remedial measures in their own area.
- Recycling/avoiding waste as processes with
  less harm to environment.
- School and household as avant-garde for a future oriented environment.
- Basic processes, materials, and tools in manufacturing and process
  technology.
- Technical drawings, mounting- and operating instructions.
- Outlining, planning, and manufacturing simple products.
- Assessing products and manufacturing processes.
• Safety rules and their application.
• Fundamentals of organization and automation of work processes in crafts and industry and their transfer to simple productions.
• Assessing impacts of labor division, mechanization, and automation on working place, change of vocations and employment structure as well as the living-standard in an industrial society.
• Testing and assessing technological products from a consumer’s view.
• Planning and using devices for multiple manufacturing.
• Working appropriately and safely with selected tools, devices, and machine tools.
• Vocations from the areas material processing and manufacturing.

5.2 Transportation and Traffic

• Structure and function of selected systems for transportation and traffic.
• The role of man as a part of the system.
• Former and future development of systems for transportation and traffic.
• Designing and making models of conveyances.
• Dismantling and re-assembling real objects.
• Assessing the interactions and interdependence of benefits, safety, economic factors and ecological damage.

5.3 Supply and Waste Management

• Technological systems of supply and waste management and judging them with economic and ecological criteria.
• Simple models and real objects of systems for supply and waste management.
• The interdependence of the employment of raw material and energy on the one hand and of pollution on the other hand.
• Former and present problems of supply and waste management in an
industrial society, cleaning of air, water, and earth.

- Possibilities of saving energy, avoiding waste and recycling.
- Sustainable systems of energy supply.
- Vocations in the area supply and waste management.

### 5.4 Information and Communication

- Designing, making, testing, and comparing simple systems of information and communication.
- Selected former and present processes of control and information technology and assessing their meaning for man.
- Designing and making devices to control technological processes.
- Recognizing and using controlling as a technological principle.
- Automating simple processes with electric/electronic circuits.
- Assessing and judging the impact of automation on man in different areas of life.
- Realizing basic electric and electronic circuits on different stages of development.
- Solving technological problems with logic circuits.
- Applying computers to control processes and for drawing.
- Assessing flexible applications of computers for solving specific technological processes.
- Designing simple programs and modifying ready-made programs to solve problems.
- Analyzing the impact of computers on different areas of life.
- Vocations in the areas of information and communication.

### 5.5 Construction and Built Environment

- The main properties of important construction materials and their suitability in different areas of application.
- Basic principles of planning buildings under the aspects dimension and integration of rooms, cardinal point, sound-absorbing and economy.
- Drawings and sketches
- Basic principles of statics and construction.
- Planning and executing simple construction projects in model or reality
- Recognizing that buildings must be both adapted to the need of man and environment friendly.
- Craftsman’s and industrial ways of building.
- Political planning processes and laws.
- Planning rooms under the aspects health, psychological effect, sociology, ecology, and economy.
- The difference between the “merchandise” dwelling and other merchandise.
- Vocations in the construction area.

References
4. Standard DIN 66201
1. Introduction

Various problems - for instance, environmental/natural resource/energy issue in the global scale, social problems caused due to the lack of the information morals and ethics of engineers, etc. - have come to occur as science and technology have advanced. In recent years, the situation is such that the conventional technology innovation and view of ethics are not capable enough to solve those problems, while it seems that technology continues to be innovated and new technologies to be developed one after another. In order to deal with this changing society with new or innovated technologies, those who are engaged in occupations that somehow related to technology and the users of the technologies are required to have a new set of value to make an appropriate judgment. “Technology Ethics” is a set of standards based on which the judgment is made. Developing this kind of ethics in people is a compelling task that society should tackle right now, not only in business world but also, and more importantly, in school education for the Technology Ethics education to be more widely received. The education should be provided especially in compulsory education as soon as possible. In this paper, “Technology Ethics” is referred as “technology ethics that all people are required to have in the future society”.

2. Concepts Concerning Ethics

Concepts concerning “Ethics” comprise of “morality” and “law”. The relation of these components and “Ethics” can be described by the diagram below.
Kojien defines “morality” as “a code of conduct that is generally approved in society.” This code of conduct is considered to be implicit, reside inside of each individual and widely recognized by members of the society, while “law” is defined as “a code of conduct to maintain law and order of society” and is considered to be the code of conduct accompanying explicit enforcing power generally by the government authority. “Ethics” is defined as “Rational on which moral code of conduct is based in a real context,” and is considered to be the code of conduct that lays foundation when one takes an action in society. Here, the term “code of conduct” refers to “a set of standard that judgment, evaluation and action are based on.”

3. Ethics Concerning Technology

As shown in the Figure 2, there are three hierarchies in the ethics in technology.

1. Ethics in Human: This is the ethics that helps to perceive the value of technology in relation to the question of “what is human?”, the most fundamental question of ethics.

2. Ethics in Technology: This is the ethics that helps to perceive from the point of a global citizen the ideal status of human society in connection with
technology.

3 Ethics of Engineers: This is the ethics concerning engineers as a practitioner of technologies in today’s society where laws, structures and systems are built in order to ensure the safety of the use of technology.

As you see from the above, the technology ethics in technology education mainly has to do with 2) “Ethics in Technology” which is based on the universal 1) “Ethics in Human.” Meanwhile, 3) “Ethics of Engineers” is applied to professional engineers, on top of 1 and 2.

4. Engineer Ethics

One of the reasons why “Engineer Ethics” was introduced to Japan is a quality assurance issue when providing technical services in the globalizing economy. On the back of this global trend, JABEE (The Japan Accreditation Board for Engineering and Technology) was founded in November 1999 as the Japanese charter of ABET (The Accreditation Board for Engineering and Technology). JABEE defines “Engineer Ethics” as the following 3).

Definition of “Engineer Ethics”

All systems for the codes of conduct that enable an engineer to judge
good and bad, justice and injustice, or other associated values of a conduct that is necessary to make an economical use of the power of the nature for the sake (value) of humans, by fully utilizing his mathematical/scientific knowledge acquired through researches, experience and practices. It also includes continuous and critical investigation of the systems and the capability to make judgment based on the systems.

This definition entails three different perspectives.

Three perspectives of “Engineer Ethics”

1. All systems for the codes of conduct that engineers conform to
2. Intelligent activity of continuous and critical investigation of those systems
3. Capability to make judgment

These perspectives indicate that one should master “Engineer Ethics” not only through knowledge about the systems for the codes of conduct, but also through acquiring perceptive powers and judgment capability in a practical manner, upon which the knowledge is based. This indication also applies to practical/first-hand-learning-oriented technology education and its concept is very close to that of engineer ethics.

Next, Figure 3 shows the relations between engineer ethics, knowledge/skill and liberal learning.

**Figure 3** Relations between Engineer Ethics, knowledge/skill and liberal art

This figure shows developing discipline of engineer ethics in someone requires not only the acquisition of professional knowledge/skill, but also
general knowledge and liberal art on which the professional knowledge/skill is based. Also in technology education, it is important to have general knowledge/liberal art as a human being and as a basis for the acquisition of the knowledge and skill regarding a certain technology, which is essential for technology education.

5. Ethics Education in the Course of Study

5.1 Ethics Education at Lower Secondary School

This section will take a look at moral education of which concepts are almost the same as the ethics education stated in the Course of Study. The Course of Study for Lower Secondary School stipulates that moral education is supposed to be provided throughout the whole educational activities in such a way that moral education is appropriately embedded into each and every subject education. This indicates how necessary moral education - or in other words, ethics education - is in Industrial Art & Home Economics class at lower secondary schools. The Course of Study also mentions that the objectives of the moral education is to develop morality as a foundation for human formation. Here, the morality is defined as “a characteristic of the personality that enables one to do moral activities for the purpose of living according to the true nature of human beings and better life. This characteristic forms a foundation of one’s personality.”

5.2 Ethics Education in Lower Secondary School Industrial Art & Home Economics Class

The Course of Study Guidebook - Industrial Art & Home Economics - points out that deepening the understanding of the relations between life and technology is important in order to make an appropriate use of technologies. The guidebook also says that nurturing in pupils an attitude that appropriately select information and technology that are necessary to improve their lives, so that their lives can be better and more developed as a result of the appropriate use of technology. To that end, the pupils need to be taught how to objectively judge/evaluate the nature and application of certain technology, and proactively use the technology.
All these commentaries indicate that the future society needs the ethics for the “appropriate” use of technology, and to that end, one needs to possess solid thinking and knowledge, as well as an ability to evaluate from objective and multiple perspectives. Therefore, developing the discipline of technology ethics in lower secondary school Industrial Art & Home Economics class is indispensable.

6. Ethics Education in Technology Education

The Figure 4 shows the structure of technology education in relation to technology ethics, on the basis of the issues discussed in the preceding sections of this paper.

![Figure 4 Structure of technology education in relation to technology ethics](image)

In technology education, before taking any action regarding technology, it is important for one to utilize knowledge/skill learned at school (selection/process of information), to consider continuously and critically the systems for code of conduct in order to evaluate the value of the action, and then judge the action. Based on this thinking steps, technology ethics in technology education can be defined as follows.

**Definition of Technology Ethics in Technology Education**

*All the systems for code of conduct that evaluate actions concerning technology that pupils take by using knowledge/skill acquired through school education. This entails continuous/critical investigation of the*
This definition indicates the following objectives of technology ethics development in technology education.

Developing Objective of Technology Ethics in Technology Education

To understand impacts that technology may give to human beings and society and develop capability and attitude to make appropriate judgment regarding the use of technology.

1. To acquire knowledge/skill concerning technology
2. To understand the systems for code of conduct concerning technology
3. To be able to make continuous/critical investigation of the systems for code of conduct
4. To be able to make judgment based on the systems for code of conduct

In the course of developing technology ethics in technology education, acquiring knowledge/skill concerning technology should come first. Secondly, one is required to understand the systems for code of conduct based on which the actions concerning technology are evaluated. Then, it is important to develop appropriate judgment capability through continuous/critical investigation of those systems, and actually make judgment and take action by using that capability.

A comprehensive study of reports from both domestic and overseas academic societies, the Course of Study for lower secondary schools as well as its guidebooks has revealed that the following areas of issues can be taught as technology ethics in technology education.

Areas of Technology Ethics in Technology Education and Examples

Safety Ethics

Safety Management, Safety Guidance, Regulation of Use for Practical Rooms, Safety Regulation for the Use of Equipment, Product Liability, View of Diligent Work Leading to View of Occupations
Ex) Maintenance/Check-up of Tools/Machines, Cleanliness of Practical
Shops, Cleaning after Practical Classes, etc.

- Environmental Ethics/Life Ethics
  - Environment Protection, Energy Saving, Resource Saving, Recycle, New Material, New Energy, Cultivation and Environment
  - Ex) Effective Use and Recycle of Material, Effective Use of Electric Devises, Understanding Impact of Agrichemicals to Environment, etc.

- Information Ethics
  - Protection of Privacy, Copyright, Computer Crimes, VDT Health Problems
  - Ex) Utilization of Information and Protection of Privacy, Observing and Protecting Copyrights of Music/Audio Visual software, How to Cope with Computer Crimes, etc.

Safety Ethics, Environment Ethics, Life Ethics and Information Ethics are all possible areas for the technology ethics discipline. Please note that there’s no clear distinction between Environment Ethics and Life Ethics at the lower secondary school level, as the two areas of ethics are very closely related. In Safety Ethics, the main focus is placed on ensuring the safe educational environment for pupils.

Lastly, the figure 6 shows the learning process of technology ethics development in technology education.

![Figure 6 Learning Process of Technology Ethics Development in Technology Education](image)
This learning process was built based on the concept of engineer ethics that one should plan his/her own action as a practitioner of technology, as well as the technology education know-hows reported by the Japanese Society of Technology Education. Technology education has been practicing a number of learning by problem solving so far, and in many cases, the learning subjects were certain “things” or “information”. This learning process can be used in the same way as the conventional learning processes by replacing the learning subjects with “actions”. The followings show more details of each learning process. Meanwhile, the term used here as “actions” refers to behavior with conscious will aim at solving problems.

1. “Recognize” of Problem: To be able to analyze, investigate and objectively recognize problems occur in the course of taking actions concerning technology.

2. “Plan” of Action: In order to solve the problem that has been clearly understood, consider the most appropriate action that one can think of and clarify the details of the action. On the basis of the knowledge/skill concerning technology that has been acquired and the systems for code of conduct to evaluate the action.

3. “Do” of Action: Do the action concerning technology, according to the plan that has been clarified.

4. “See” of Action: Review the action taken, compare it with the plan and evaluate its appropriateness.

In addition, reconsider the problem, the plan and the systems for code of conduct and revise the action, based on the feedback given in the review process. Each process is reviewed individually after execution. By repeating this series of learning process, pupils should be able to master technology ethics of higher level.

7. Conclusion

This paper was intended to shed light on technology ethics in the Japanese technology education with the help of some reference materials and the Course
of Study. For the future development of technology ethics in technology education, practical approach is more important than theoretical researches. In particular, it is vital to develop teaching materials and learning processes for practical/experiential learning about subject areas for technology ethics (safety, environment, life, information, etc.)

References
10) Same as 8)
Industrial Technology Education into which Occupational Safety and Health was Incorporated

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1. Introduction

The article 27 of the Constitution of Japan states “All people shall have the right and the obligation to work”. To work, in other words, to perform the right to work, is an important activity as a means to achieve the ideals and the objectives declared in the Constitution that people all over the world live in peace and that ensure well-being of all people of Japan. However, cases that one’s health is damaged by works have never ceased to occur throughout the history. Despite enormous effort that has been paid in order to develop a social structure for the protection of workers’ health and to apply it to worksites, occupational accidents and diseases have never disappeared. This fact indicates that it is far difficult than it seems to work and maintain one’s health at the same time. What needs to be done to enable a worker to work and also maintain his/her health so that the result of work can contribute to people’s life and well-being for the better? Technology education embedded with occupational safety and health can play a vital role as one of the answers to this question.

2. Statistics of Work-related Accidents and Diseases

2.1 In the World

ILO estimates that 2.2 million cases of work-related deaths, 270 million cases of non-fatal work-related accidents causing 3 days and over absence, and 160 million cases of non-fatal work-related diseases occurred in the year 2001. The number of work-related death was up by 10% from the estimation for 1988, which is due to the increase of work-related death in developing countries, while that of developed countries has declined. (The term “work-related” means the total number of cases of which single cause or one of the causes is
work. In this paper, accident or disease cases of which single cause is work will be termed as an “occupational accidents” or “occupational diseases”.

2.2 In Japan

1) Occupational accidents

The annual number of work-related deaths in Japan has been on the decline since 1961 when it reached the record high of 6,712. Then, the number was 6,048 in the year 1970; 3,009 in 1980; 2,550 in 1990; 1,889 in 2000; 1,472 in 2006. The number of deaths and injuries causing 4 days and over absence per 1,000 workers was 9.1 in 1980, and it declined to 4.6 in 1990, 2.8 in 2000 and 2.4 in 2005.

This shows occupational accidents has been on the decline in Japan, however, the absolute number of death and injuries causing 4 days and over absence in 2006 still stood at 120,000 which by no means should be considered as a small number. The breakdown of the types of the accidents occurred in 2005 is; fall to same level, 18.0%; fall to lower level, 17.8%; caught in objects, 15.3%; odd worker motion, 9.6%; contact with objects 8.8%; traffic accident, 7.4%, etc.

2) Occupational diseases

Figure 1 was created based on the published statistics of the Ministry of Health and Labor and shows the trend of the number of workers who were forced to be away from work for 4 or more days due to occupational diseases and newly claimed workers’ accident compensation since 1980. Diseases caused by injuries have been on the top throughout the period, declining rapidly toward the first half of the 90’s and leveling off in recent years. Low back pain consists much of the diseases caused by injuries (82% in 2006), followed by the diseases caused by working styles that imposing excessive physical load and by inhaling dust, both of which had gradually declined toward the first half of the 90’s and then increased once, and again has been on the decline recently.

The diseases caused by working style are namely hand-arm vibration disorder, cervico-brachial disorder, etc. The diseases caused by inhaling dust include pneumoconiosis and associated tuberculosis, bronchitis, etc. Follows next in the statistics is diseases caused by physical factors (excluding cancer), which increased once around 1987 and has been leveled off since 1989. The
diseases caused by physical factors include noise-induced hearing loss and heat stroke. The number of workers who have undergone other diseases than the above mentioned ones is relatively small. Although not obvious from the statistics, the number of cases of occupational cancer and the diseases obviously caused by work-related operations are on the increase in recent years. The increase of occupational cancer is mainly due to the increase of asbestos-induced cancer. The diseases obviously caused by work-related operations mainly include cerebrovascular diseases, heart diseases and mental diseases all of which are due to excessive physical and mental load.

That’s all for the outline of the statistics published by the Japanese government. It is important to note that the number of cases of some occupational diseases has declined but that of others has increased, and that there has been quite a few cases that was not filed for workers accident compensation as well as that occupational dermatosis cases exist in the far greater number than shown in the statistics, as dermatosis oftentimes cause less than 4 days of absence from work.

3. Necessity of Safety and Health Education at School

Although the incident rate of work-related accidents and diseases varies from country to country, it is an important task for each and every country to decrease the rate. Take preventive measures is essential in reducing work-related accidents and diseases. Many governments, companies and workers have been striving for less work-related accidents and diseases, and one of the measures taken was occupational safety and health education which oftentimes provided as part of in-company training. However, this paper proposes that occupational safety and health education needs to be provided as part of school education because of the following reasons.

Firstly, there’s the fact that injuries occur in classrooms during experiments and workshops. Occupational safety and health education at school will help pupils learn in safer and healthier environment.

Secondary, occupational safety and health education at school will help pupils balance safety/health and work after graduation and becomes a full member of society. The OSH education will also help pupils acquire basics to
produce a product that is less harmful for users or consumers.

As shown in the preceding paragraphs, the incident rate of work-related accidents and occupational diseases in Japan has been leveled off in recent years. However, the absolute number of cases are still large, and loss of victims, their families, companies and society is huge. There are countries in the world such as Sweden and UK where the fatal accident rate is lower than Japan, while maintaining high economic competitiveness.¹) Learning the basics of occupational safety and health at school before joining workforce of society will surely result not only in a further reduction of incident rate of work-related accidents and diseases but also in the improvement of labor productivity and in safer, healthier and more competitive Monozukuri (making things) environment.

4. The Course of Study

In Japan, the Course of Study for lower secondary school’s Technology/Home Economics²) and Health/Physical Education³) , and that for upper secondary school’s Health/Physical Education⁴) and Industry⁵) mentions the contents of occupational safety and health education as shown in Table 1, which covers widely from the safety and health regarding the use of machines, tool and materials to fatigue, stress mental health and workplace safety and health management. If all the areas mentioned in the Course of Study are covered in the aforementioned subject classes, it would be almost all that is required of occupational safety and health education at school.

5. Technology Education and Occupational Safety and Health

If the Course of Study is appropriately practiced at lower/upper secondary school, there would be no problem. However, the reality seems that the Course of Study is not fully applied. The paper proposes that teacher training and curriculum/teaching material development are essential to achieve the full practice of the Course of Study.

The occupational safety and health in technology education should be most importantly considered. It is quite necessary for technology education teachers who teach the basics of making things to pupils to have the capability to teach
occupational safety and health.

The following factors could cause injuries, suffocation or diseases at worksites.

Injuries are caused usually by a combination of physical factors such as temporary/permanent constructions, machines, materials, tools, vehicles, luggage, etc., and human factors such as negligence, error, etc. that oftentimes results in downfall, being caught in objects, falling to same level, struck by flying objects, traffic accidents, etc.

Suffocation is caused by working in the places like underwater or in underground basements/tanks, where ill ventilated and of low oxygen concentration due to oxygen consumption by oxidization of metals and microbial respiration and oxygen replacement by exhaust gases.

Work-related diseases are caused by physical, chemical, biological and work style factors. Table 2 shows the main factors of each category, the types of jobs that are potentially exposed to those factors and some example of diseases that might be caused by them.

It can be reasonably concluded that technology education embedded with occupational safety and health can make a great contribution in control factors that might cause injuries, suffocation and diseases at work places and also to producing the products that are safe and healthy for consumers.

6. Conclusion

In Japan, the breakout of work-related accidents or of conventional occupational diseases is becoming things of the past, as many people’s efforts have successfully revealed more and more harmful substances to the public. On the other hand, however, increasing number of jobs that require excessive use of certain part of body such as upper body or eyes, sitting in one place for long hours, strong mental pressure and long work hours have been widely observed. As a result, work-operation-related diseases such as cervico-brachial disorder, low back pain, eye strain, excessive fatigue, depression, heart diseases, cerebrovascular diseases have surfaced these days. Despite the progress of mechanization and automation and the introduction of handy equipment or tools to work places, new types of physical and mental load is
created at work places, and working is still anything but easy. It is a future challenge that how and what to teach regarding work-related accidents/diseases prevention in technology education curriculum, however, promoting technology education embedded with occupational safety and health is one of the fundamental measures that meets the great social needs of balancing work and safety/health.
Figure 1. The Number of Occupational Diseases and Accidents Claimed for Compensation (Causing 4 or More Days of Absence)
<table>
<thead>
<tr>
<th>Subject Name</th>
<th>Lower Secondary School</th>
<th>Upper Secondary School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economics, 2nd Section, Technology Field</td>
<td>Technology and Making Things: Processing methods that are suitable for the material, appropriate use of tools and equipment. Cultivation of plants: Proper planning and cultivation of plants.</td>
<td>Proper meals, exercise, rest and sleep according to age and life environment are necessary to maintain and improve one's health. Environment, food and work are deeply linked with the maintenance and improvement of health. Health/safety management according to work style/environment are important in preventing occupational diseases and accidents.</td>
</tr>
<tr>
<td>Health/Physical Education</td>
<td>Health/Physical Education</td>
<td>Industry 43rd Section: Industrial Chemistry 44th Section: Chemical Engineering 45th Section: Industrial Material 50th Section: Ceramic Technology (The columns below only show the contents for Industrial Chemistry, and other sections are omitted here.)</td>
</tr>
<tr>
<td>Making Things:</td>
<td>Teach how the fatigue caused by the use of computers or other information-related devices can be observed, how to take rest, etc.</td>
<td>Help students understand that character and frequency of occupational diseases and accidents have changed over years according to changes in work styles and environment, and also that safety management for accident/disease prevention and healthcare of workers are necessary at workplaces. Help students understand that maintenance and improvement of workers' health requires comprehensive measures that care both physical and mental health along with the safety management and healthcare promotion at workplaces. It should be indicated that the focus of these measures is on mental healthcare such as stress recognition assistance and guidance for relaxation, etc.</td>
</tr>
</tbody>
</table>
Table 2. Examples of work-related factors that could cause diseases, the kinds of jobs that are exposed to those factors and resulting diseases (Note that, the factors, jobs and diseases in the table are just representing the rest that are not shown)

<table>
<thead>
<tr>
<th>Physical factors</th>
<th>Examples of factors (jobs)</th>
<th>Examples of health disorders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-ionizing radiation</td>
<td>(1) Ultraviolet rays (Welding), (2) Infrared rays (Glass works), (3) Laser beam (Cutting metal)</td>
<td>(1) Conjunctivitis, (2) Cataract, (3) Burn</td>
</tr>
<tr>
<td>Ionizing radiation</td>
<td>Medical treatment, Nondestructive test</td>
<td>Dermatitis, Cataract, Leukemia, Lung cancer, Skin cancer</td>
</tr>
<tr>
<td>Barometric pressure</td>
<td>Hyperbaric (Diving, Caisson)</td>
<td>Decompression sickness</td>
</tr>
<tr>
<td>Temperature</td>
<td>(1) Steel mill, (2) Freezer</td>
<td>(1) Heat stroke, (2) Frostbite</td>
</tr>
<tr>
<td>Noise</td>
<td>Forging, Cutting</td>
<td>Hearing loss</td>
</tr>
<tr>
<td>Vibration</td>
<td>Whole body vibration (Heavy equipment), Local vibration (Vibratory tools)</td>
<td>Low back pain, Hand-arm vibration disorder</td>
</tr>
<tr>
<td>Toxic substance</td>
<td>Pesticides (Agriculture), Organic solvents (Painting, Cleaning, Printing), Metals (Soldering, Welding)</td>
<td>Disorders in nerves or reproduction, Disorders in nerves, liver or kidney, Disorders in blood, nerves or kidney, Metal fume fever</td>
</tr>
<tr>
<td>Exhaust gases</td>
<td>Carbon monoxide poisoning</td>
<td></td>
</tr>
<tr>
<td>Allergen</td>
<td>Isocyanates (Urethane resin molding, Painting), Plants (Jobs using flour, buckwheat or rubber), Shampoo (Hair dresser)</td>
<td>Asthma, Asthma, Dermatitis</td>
</tr>
<tr>
<td>Carcinogen</td>
<td>Asbestos (Construction worker, Heat insulator), Chromates</td>
<td>Lung cancer, Mesothelioma, Cancers in respiratory organ</td>
</tr>
<tr>
<td>Benzidine (Dyeing)</td>
<td>Bladder cancer</td>
<td></td>
</tr>
<tr>
<td>Dust</td>
<td>Mineral dust (Stonemason), Fumes (Welding)</td>
<td>Pneumoconiosis</td>
</tr>
</tbody>
</table>

| Biological factors | Virus and bacteria (Medical treatment) | Tuberculosis, hepatitis, AIDS |
| Working styles | Transportation, Construction, Car driver, care giver | Musculoskeletal disorders |
| Awkward posture | Assembling, Computer work | Cervicobralial disorders |
| Repetitive task | Computer work | Eye strain, Dry eyes |
| Load on eyes | Long working hours (Sales, Engineering, Driving) | Ischemic heart diseases, Cerebrovascular diseases |
| Physical/mental load | Night work (Nursing, Manufacturing, Driving) | Sleep disorder, Stomach ulcer |
| Psychological load (Managing, Engineering) | Stomach ulcer, Suicide |

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Emerging Trends in Asia Pacific, Impact on TVET and CPSC’s Response

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1. Background
The Colombo Plan Staff College for Technician Education (CPSC) is an autonomous specialized agency of the Colombo Plan that embodies the concept of the collective inter-governmental effort towards the social and economic development of member countries in Asia and the Pacific region. CPSC facilitates transfer and sharing of developmental experiences in the Human Resource Development through Technical and Vocational Education & Training (TVET) amongst the member countries within the region. The objective of CPSC as an intergovernmental organization is to improve the quality of technician education and training in the Member Countries (MCs) through capacity and capability building exercises.

Since its establishment in 1973, CPSC has made great leaps and strides in enhancing TVET systems through relevant education & training programs, consultancy projects, research and development activities and information and communication technology services. The latest among its achievements is the establishment of the regional accreditation and certification body known as Asia Pacific Accreditation & Certification Commission (APACC).

This paper discusses some of the emerging trends in the Asia Pacific Region which have impact in the TVET system and development of Asia Pacific countries. In the light of the emerging trends, the shaping of CPSC’s vision, mission and strategic direction are shared with other network of development organizations with important roles to play in strengthening TVET programs and services. The aim is to build an understanding of key priorities towards creating opportunities for collaborative endeavors in TVET on common goals. As a
regional inter-governmental organization, CPSC has the mandate to draw specific strategies in pursuit of its mission. As one of the catalysts of TVET development, it has the responsibility to pro-actively share its competencies and review the environment in which other key players in TVET move and together shape institutional strengths, towards greater sharing of TVET perspectives and practices. A general strategic framework on how to achieve strategic responses has also been outlined in this paper.

2. Knowledge Society & a New Paradigm

The twenty first Century presents a radically different economy and society, which is likely to have profound implications on TVET. The TVET system in the Asia & Pacific region must adapt to this key features which include Globalization, ICT Revolution, Economic Restructuring, Emergence of Knowledge Society and Rapid Knowledge Obsolescence. Globalization generates new demands, structures and systems requiring new skills and knowledge. In today’s global economy driven by knowledge, the foremost wealth of a firm is its human capital or knowledge assets. The Organization for economic Co-operation and Development (OCED) estimates that already more than half the wealth of the advanced industrial society is derived from knowledge capital. The knowledge-based economy recognizes the key role of information-based technologies in providing a basis for the generation, management and utilization of knowledge as never before. The developing countries are also fast moving towards knowledge economy and thereby present new challenges in the TVET systems of these countries.

The Second International Congress on TVET organized by UNESCO pointed out that from economic growth to human development the bridge has to be built through the teachers who are well trained. The most important ‘agent of change’ in ‘Knowledge Society’ is its teachers. UNESCO-UNEVOC, CPSC, ADBI and various international organizations highlighted the need for innovations and quality improvement in training of TVET teachers to meet the challenges in knowledge society.

One of the major focuses of TVET in Asia & the Pacific region is on poverty alleviation, which is one of the greatest challenges for the international
community in the 21st Century. Technical Vocational Education and Training (TVET) can play a very important role in meeting these challenges.

The Millennium Development Goals (MDG), a declaration among UN Member nations to end human poverty, was adopted by Heads-of-State and Governments of 189 countries in the year 2000. MDG calls for cutting poverty by half by 2015. Strategy to end poverty has to be multi-sectoral and will require a committed Action Program for institutional capacity and capability building and empowerment of people. Education for all (EFA), TVET for All and ICT are the keys to empower people. Building basic capital for economic growth, employment generation, and poverty alleviation require:

a) Building human capital through basic education, technical and vocational education and training, healthcare and nutrition;

b) Strengthening knowledge and information capital through access and ability to use scientific, technological, and market information.

c) Building financial capital for the poor through micro-credit and TVET intervention.

The following diagram (Figure 1) describes a model of the dramatic changes in terms of economy, worker orientation and output. They are seen as positive developments in the society influenced by the changing times, needs and demands.

![Figure 1 Changing Paradigm](image-url)
3. Emerging Trends

This changing paradigm generates different types of trends in technology, economy, social and TVET system that are necessary in building a highly systematic vision for CPSC.

3.1 Technology Trend

First let us see the technological trends that are sweeping across Asia and the Pacific region. Continuous changes and technological advancements are happening, and their benefits are envisioned towards making greater strides in the way TVET systems are managed and run in the member countries. The major shift in technology is dominated by the move from narrow band to broad band, divergent to convergent, wire to wireless, local to global and finally integrated technology, as provided below:

<table>
<thead>
<tr>
<th>Moving From</th>
<th>Moving To</th>
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<tbody>
<tr>
<td>Narrow Band</td>
<td>Broad Band</td>
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<tr>
<td>Divergent</td>
<td>Convergent</td>
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<tr>
<td>Wired</td>
<td>Wireless</td>
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<tr>
<td>Local</td>
<td>Global</td>
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<tr>
<td>Electronic</td>
<td>Integrated</td>
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</tbody>
</table>

With these changes, deepening of technical knowledge raises more demand for workers with competitive edge in performing work fit for high-end and emerging technologies. TVET systems in Asia and the Pacific region, hence, CPSC must look into satisfying the skills requirements of emerging technologies in the 21st century.

Furthermore, the excessive pace of technological changes have emphasized integrating technological knowledge and skills in education and training to expand life long capabilities of a knowledge-based worker. Keeping this, the phenomenon on the life and span of retention of knowledge is reinforced (Figure 2). It has been observed that the economic pace of technological change makes 50 percent (50%) of computer knowledge irrelevant within one year, technological knowledge in three years, specialized vocational knowledge in five years and higher education knowledge in 10 years.
Under this trend, TVET’s role is important to consistently provide a learning platform where knowledge can be updated and enriched as required by the job market and the workplace. Today’s integrated technology namely information & communication technology (ICT), bio technology, nano technology, energy technology, space technology and entertainment technology, are characterized as interdisciplinary, oriented to Research and Development (R&D), information-intensive, has shorter life cycle and globalized. In here, CPSC must develop the mechanism to explore more avenues to go beyond the conventional training integrating generic soft skills with domain specific hard skills.

Technological skills are thus the necessary agents to create knowledge workers, who are, by themselves, molded to become Change Agents. The role of technicians bears importance on the productivity of organizations. CPSC can
do so much in shaping the technicians in the light of the technological events and appreciation of fast-paced trends.

Figure 3 below illustrates the evolution of work and work orientation in the area of focus of organizational technology structure and the main initiator of change in the workplace. It has been observed that in the era of integrated technology and network structure and innovation, knowledge worker will be the key change agent in the workplace.

![Figure 3 Evolution of Work in High-Tech Organizations](image)

**Figure 3  Evolution of Work in High-Tech Organizations**

### 3.2 Economic Trend

The 21st Century economy points that material value has gone drastically obsolete with the coming of knowledge economy run by knowledge workers. Knowledge economy places more value on the knowledge that catalyses technical innovations and achievements which propel economic gains. This
signifies the important role of TVET as breeding ground for the necessary skills and work qualifications.

It has likewise become a commonplace that the globalizing world has dictated, in part or in whole, the mobility and economy of trades and human resources. The opening of trades subsequently opened new doors where there is an encouraging borderless movement of technology, product, services and labor, contributing to the expansion of economic activities.

CPSC, as a regional hub of learning, has big role to play in creating a borderless and seamless mechanism to make possible mobility among the knowledge workforce. Recognizing its regional role, the amalgamation of country to country and region recognition of skills through harmonized standards and qualifications could contribute to the realization of the overall regional economic aspirations.

3.3 Social Trend

Reducing poverty, promoting sustainable development, equity and inclusive growth are key social trends that CPSC, as a multi-cultural and inter-governmental organization, is faced. It is a social responsibility for the CPSC to link up its development commitments and activities for its member countries with the United Nations Millennium Development Goals (MDGs) upon which all national and regional agenda are anchored around to be in line with the global development initiatives.

In many parts of the world, innovative initiatives are actively undertaken to either directly achieve or contribute to achieving the MDGs. Many of these, if shared with other countries, can offer new insights for planning and implementing effective human resources development programs to help in specifically achieving life-long learning and skills training necessary to keep stable employment and supply labor market demand.

The goal of CPSC should be towards approaching poverty reduction through
skills development and training, keeping in view that “if education is the key to poverty alleviation, then Technical and Vocational Education and Training (TVET) is the master key that can unlock the doors to better quality of life through job skills. Having decent work and sustainable life skills is believed to help re-direct societies from the risks of being locked in the bondage of poverty.

3.4 TVET Trend

All the above trends have some profound implications on TVET systems in Asia and the Pacific region. The changing nature of the world of work, especially due to globalization and technological changes, economic changes and social changes, require an understanding how these changes impact upon the quality of TVET systems. Unfortunately, TVET in many countries remain locked in the role of being a mere supplier of skilled labor to industry and is thereby unable to respond effectively to the emerging needs.

![Emerging TVET Trends](image)

**Figure 4** Emerging TVET Trends

Policy initiatives and strategy developments are diverse and manifold for transforming and repositioning the TVET systems of CPSC member countries for their sustainability and global competitiveness into the New Millennium. With the technological revolution, the challenge in TVET will not only focus on the development of new and relevant skills but also on the flexible and
innovative delivery systems to meet the required skills and on the development of institutional capacity for lifelong learning. CPSC has taken a leading role in meeting the regional challenges of TVET systems of Asia and the Pacific that includes knowledge worker, harmonizing qualification, skill development for non-formal TVET, integrating ICT in TVET, life long learning, generic soft skills, sustainable development and quality management system as depicted in Figure 4. These challenges are based on the regional trends like knowledge-based economy, mobility of workforce, poverty alleviation, ICT integration, rapid technological changes, environment education and total quality management respectively as depicted in Table 2.

Table 2 Regional Issues: TVET Trends

<table>
<thead>
<tr>
<th>Knowledge-Based Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Workers: Higher Order Thinking (HOT) Skills</td>
</tr>
<tr>
<td>Mobility of Workforce</td>
</tr>
<tr>
<td>Harmonizing Qualification: Accreditation and Skills Standardization</td>
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<tr>
<td>Poverty Alleviation</td>
</tr>
<tr>
<td>Skill Development for Non-Formal TVET</td>
</tr>
<tr>
<td>ICT Revolution</td>
</tr>
<tr>
<td>Integrating ICT in TVET: Web-Based Learning (WBL)</td>
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<tr>
<td>Rapid Technological Change</td>
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<td>Life-Long Learning: Generic Soft Skills</td>
</tr>
<tr>
<td>Environmental Conservation</td>
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<tr>
<td>Sustainable Development: Alternative Paradigm</td>
</tr>
<tr>
<td>Quality Movement and Partnership</td>
</tr>
<tr>
<td>Quality Management System: Networking and Linkages</td>
</tr>
</tbody>
</table>

4. Redefining the Role of CPSC as a regional hub in TVET in the Asia Pacific region

Under the changed context and in the light of the implication for technical and vocational education in the knowledge society, there will be corresponding changes in the role of CPSC. CPSC will now be required to act as a CATALYST in introducing changes in the various components of the technical education system; be PROACTIVE in visualizing and mapping changes in industry, technology, economy and society; and act as a FACILITATOR of the
change management process in the technical education system.

<table>
<thead>
<tr>
<th>Vision Reach Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPSC will now be required to act as</td>
</tr>
<tr>
<td><strong>CATALYST</strong> in introducing changes in the various components of TES</td>
</tr>
<tr>
<td><strong>PROACTIVE</strong> in visualizing and mapping changes in industry &amp; society</td>
</tr>
<tr>
<td><strong>FACILITATOR</strong> of the change management process in TES</td>
</tr>
</tbody>
</table>

There is a greater role for CPSC to lead in (a) assisting member countries in transformation of TVET framework in the knowledge society, (b) providing guidance and assistance in its restructuring efforts, and (c) modifying the training and development strategies, program offerings and research & development efforts. Therefore, CPSC should be the leading inter-governmental organization in the field of Technical and Vocational Education and Training (TVET) for the member countries in the knowledge era. CPSC needs to reposition itself in the early years of 21st Century.

5. Major Thrusts and Strategic Focus

It has been said that education is the key for development, but TVET is the master key for poverty reduction and employment generation. Capacity and capability building should be a core and strategic thrust of CPSC to improve the region’s TVET, which may include but not limited to, (1) training & development, (2) skills development, (3) instructional materials development, (4) learning resources development, (5) institutional development (6) curriculum design and development and (7) research & development. This will build on the following strategic focus:
6. Towards Harmonious Development

CPSC has the unique position in Asia and the Pacific region being a Technical Cooperation for Developing Countries (TCDC) organization. It can facilitate actions to link efforts, create opportunities and cultivate the spirit of south-south cooperation to address regional issues and strengthen regional integration in view of the emerging TVET trends.

TVET, seen as an integral component of human resources development, will subsequently bring serious impact to the building of social and economic capacities of a country.

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Curriculum and Instruction”. ASCD: Alexandria, VA.
1. Introduction

Korean government has placed great importance on fostering skilled technicians since last century, industrial society, not to fall behind in advanced international industrial society. These efforts were successfully fulfilled through technical high schools, and as a result Korea ranked 13th in world’s trading in 2006.

Korean economy had accomplished about $20,000 of GDP in 2007. It means that our country’s economic growth was not able to depend upon the last successful development patterns which are mainly consisted of medium technology and medium and low-prices of products any more. We need to change the existing development pattern to advanced country’s growth pattern; self-directed learning methods to develop the industrial competency through technical innovation by ourselves.

It is successfully achieved when the changing the economy growth pattern is directly connected with changing the vocational education pattern in schooling system. In early times, Plato emphasized that a nation will be made as its nation’s people are educated. This means that our future can be easily seen by present student whose level of learning contents and trends of education are taught in schooling system. The accountability on experts of our country’s education field became increased in their major fields; to reasonably put industrial development paradigm shift into vocational education paradigm shift in vocational schools.

Jeremy Rifkin(1995) forecasted in ‘the end of work’ that 90% of the present workplace will be disappeared within 20~30 years to come. The number of workplace will be to rapidly lessen not only blue color workplace but also
white color workplace. Therefore, the changing of labor market in manpower supply and demand plan was emphasized to be ought to be connect with curriculum development to adjust the trends of knowledge based on society in schooling system.

The essential values of this century are characterized by creativity, diversity, and individuality for problem-solving, making decision, cooperative learning and so on. Furthermore, knowledge is becoming the driving factor in knowledge economy. These new spirits of the 21st century means, the technical high schools current curriculum, which is technique-centered education, should change their identification as talent-centered education.

The ability of self-directed learning is able to be achieved through main part of CBE(Competency Based Education) in Individualized learning. In meritocracy job skills are required for the person to be recognized in workplace.

Therefore necessary job skills in future work field such as factory or company and so on should be provided the students in their enrolled school. The SCID(Systematic Curriculum and Instructional Development) was made by Robert E. Norton of CETE(Center on Education and Training Employment) of Ohio State University. It was evaluated with appropriate model for the learners to bring-up the job skills for which industries require systematically.

This paper will mainly present the actual example and procedures of the developed SCID(Systematic Curriculum and Instructional Development) by Chungbuk Semiconductor High School in Korea.

2. The status of technical high schools and their problems

Recently as influence of changes in social conditions such as improvement of GDP and tendency to have fewer children, the popularity of technical high schools declined. As the popularity declined, some technical high schools did not make their quota because of the shortage of applicants. And then technical high schools begin to concern about ‘existence of school’ seriously.

The various educational plan has been carried out with vocational high schools to solve the shortage of applicants, and to estimate the needs of workplaces in coming future society related with major fields, respectively. A
plan for specialization of the major in technical high school has been discussed and accomplished in order to upgrade the level of vocational education contents.

A technical high school which was composed of many fields such as machinery, electronics, etc., has the competitiveness through specialization high school which has just 1 major or some majors, that is, becoming, with just 1 major field, automobile high school or semiconductor high school. A specialization school from general vocational school will be strongly supported in both of budget and administration by local and/or central government.

It is necessary for the teacher of specialization vocational high school to have appropriate the teaching ability in their own major fields. Even though the curriculum of specialization vocational high school has their own instructional direction and level, some of teachers’ teaching ability is left behind new curriculum. This problem should be solved in hurry to normalize the teaching-learning of class in the specialization vocational high schools. This is the instance of putting the cart before the horse; first of all is to bring-up the appropriate major knowledge of teachers in their own fields, and then to make specialization vocational high school. Although educational policy is very excellent, the expected aim and effectiveness of it could not be attained successfully if it is not be prepared enough in draft.

3. New plan for vocational high schools

The new Korean government of which practical idea is pragmatism to begin in February 25, 2008. The revitalization for vocational education at the level of secondary school is composed of two axes; the 1st axis is the existed specialization high schools, and the 2nd axis is the Korean type of meister high schools something like traditional Germany’s vocational school. First of all in the year 2008, the government will assign the 20 meister high schools among the already existed specialization vocational high schools. And 50 meister high schools will be made step by step until 2008.

MEST(Korean Ministry of Education, Science & Technology) has a long-term plan to make 300 specialization high schools in the year to come 2009 from 130 specialization high schools until now. The other type of vocational
high schools will be arranged for the 500 or so vocational high schools which are aimed for bringing-up the basic occupation skills and comprehensive schools

4. The development of curriculum and text of Chungbuk Semiconductor High School

According to the SCID(Systematic Curriculum and Instruction Development) method, we have developed the curriculum satisfied the semiconductor industry needs. In Chungbuk semiconductor high school, the SCID workshop was held for July 23-July 26, 2007.

This SCID workshop had been designed to provide individuals responsible for vocational-technical education and business-industry curriculum and instructional development multiple opportunities to improve their knowledge and skills.

As part of this comprehensive four-day workshop, we had learned as followed

a) Key phases and components of the SCID curriculum development process
b) Alternatives for conducting needs analysis
c) Key elements and benefits of the DACUM job/occupational analysis process*
d) Specific procedures for task verification
e) Specific procedures for standard task analysis
f) Key elements of competency-based education programs
g) Factors to consider in designing instructional programs
h) Guidelines for developing learning objectives
i) Procedures for developing performance measures
j) Key components of a training program plan
k) Alternatives for instructional materials development
l) Specific process for developing learning guides
m) Procedures for identifying existing materials
n) Guidelines for developing instructional media
Specific procedures for conducting fields tests and field critiques

As mentioned above, the DACUM (an abbreviation for Developing A Curriculum) process for occupational analysis had involved 8-9 men with reputations for being the “top performers related semiconductor device” at their semiconductor device jobs, working on a short-term (for September 29-September 30, 2007 in Chungbuk Semiconductor High School) committee assignment with a qualified DACUM facilitator. Workers were recruited directly from business and industry. These workers became the Panel of semiconductor device Expert who collectively and cooperatively described the occupation in the language of the occupation. The panel worked under the guidance of a trained facilitator for two days to develop the DACUM Research Chart. The chart contained a list of general areas of competence called DUTIES and sever TASKS for each duty. Brainstorming techniques were used to obtain the collective expertise and consensus of the committee. As the Panel determined each task, it was written on a card. The cards were attached to the wall in front of the Panel. The completed chart was a graphic profile of the duties and tasks performed by successful workers in semiconductor device occupation.

The Panel also identified the general knowledge and skills required of successful workers, the tools, equipment, applies, and materials used, the important workers behaviors essential for success, and the future trends and concerns to cause job changes. The process had produced superior results for all occupational levels.
As mentioned before, the developed DACUM was carried out with relevant stakeholder groups something like as experts of semiconductor company, teachers who teach the related with semiconductor subject in school, and finally students who major for semiconductor fields. DACUM Research Chart used in the study was shown in Table 1. Table 2 showed the process of SCID at each phases. Table 3 summarized the SCID systematic approach. Table 4 is the essential contents of the student Learning Guide according to the SCID.
Table 2  Systematic Curriculum and Instructional Development (SCID)

<table>
<thead>
<tr>
<th>Phases</th>
<th>Major Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>A–ANALYSIS</td>
<td></td>
</tr>
<tr>
<td>A-1</td>
<td>Conduct Needs</td>
</tr>
<tr>
<td></td>
<td>Analysis → Conduct Task Analysis</td>
</tr>
<tr>
<td>A-2</td>
<td>Conduct Job Analysis</td>
</tr>
<tr>
<td>A-3</td>
<td>Conduct Verification</td>
</tr>
<tr>
<td>A-4</td>
<td>Select Tasks for Training</td>
</tr>
<tr>
<td></td>
<td>Task Analysis → Conduct Literacy Task Analysis</td>
</tr>
<tr>
<td>A-5</td>
<td>Conduct Standard</td>
</tr>
<tr>
<td>A-6</td>
<td>Literacy Task Analysis</td>
</tr>
<tr>
<td>B–DESIGN</td>
<td></td>
</tr>
<tr>
<td>B-1</td>
<td>Determine Training</td>
</tr>
<tr>
<td></td>
<td>Plan ▼ Develop Learning Approach</td>
</tr>
<tr>
<td>B-2</td>
<td>Develop Learning</td>
</tr>
<tr>
<td></td>
<td>Objective ▼ Develop Performance Measures</td>
</tr>
<tr>
<td>B-3</td>
<td>Develop Training</td>
</tr>
<tr>
<td>B-4</td>
<td>Training Plan ▼ Develop Plan</td>
</tr>
<tr>
<td>B-5</td>
<td></td>
</tr>
<tr>
<td>C–DEVELOPMENT</td>
<td></td>
</tr>
<tr>
<td>C-1</td>
<td>Develop Competency Profile</td>
</tr>
<tr>
<td></td>
<td>Guides/ Modules ▼ Develop Learning</td>
</tr>
<tr>
<td>C-2</td>
<td>Plan ▼ Develop Learning Plan</td>
</tr>
<tr>
<td>C-3</td>
<td>Aids ▼ Develop Learning Plans/Job</td>
</tr>
<tr>
<td>C-4</td>
<td>Develop Lesson Plans</td>
</tr>
<tr>
<td></td>
<td>Supportive Media ▼ Develop Scripts</td>
</tr>
<tr>
<td>C-5</td>
<td>Revisi ▼ Develop Scripts</td>
</tr>
<tr>
<td>C-6</td>
<td>Materials ▼ Develop Test/</td>
</tr>
<tr>
<td></td>
<td>Pilot Apparatus ▼ Develop</td>
</tr>
<tr>
<td>D–IMPLEMENTATION</td>
<td></td>
</tr>
<tr>
<td>D-1</td>
<td>Implement Training</td>
</tr>
<tr>
<td></td>
<td>Training Plan ▼ Conduct Training</td>
</tr>
<tr>
<td>D-2</td>
<td>Conduct Formative Evaluation</td>
</tr>
<tr>
<td>D-3</td>
<td>Document Training</td>
</tr>
<tr>
<td>D-4</td>
<td></td>
</tr>
<tr>
<td>E–EVALUATION</td>
<td></td>
</tr>
<tr>
<td>E-1</td>
<td>Conduct Summative Evaluation</td>
</tr>
<tr>
<td></td>
<td>Information ▼ Contribute</td>
</tr>
<tr>
<td>E-2</td>
<td>Analyze Information Collected</td>
</tr>
<tr>
<td>E-3</td>
<td>Corrective Actions</td>
</tr>
</tbody>
</table>

**Table Notes:**
- The diagram illustrates the Phases of SCID: A–ANALYSIS, B–DESIGN, C–DEVELOPMENT, D–IMPLEMENTATION, and E–EVALUATION.
- Each phase is aligned with Major Components involving various steps of curriculum and instructional development.
- Arrows indicate the flow and relationships between different stages of SCID.
### Table 3  SCID SYSTEMS APPROACH SUMMARY

<table>
<thead>
<tr>
<th>Phrases</th>
<th>Major Activities</th>
<th>Outcomes</th>
<th>Major Product</th>
</tr>
</thead>
</table>
| **Analysis** | ▶ Conduct Needs Analysis  
  - Identify job needs  
  - Identify company needs  
  - Identify trainee needs  
  ▶ Conduct Job Analysis  
  - Identify job/task duties  
  ▶ Verify Job Tasks  
  ▶ Select Tasks for Training  
  ▶ Conduct Task Analysis  
  - Identify steps  
  - Identify Knowledge needed  
  - Identify basis skills needed  
  - Identify safety factors  
  - Identify worker decisions  
  - Identify worker behaviors  
  - Identify performance standards | ▶ General Needs Identified  
  ▶ DACUM Chart or Duty and Task List  
  ▶ Tasks to be included in Training Program  
  ▶ Instructional Requirements for Each Task Including Specific Performance Standards | Training Program Competencies and Performance Standards |
| **Design** | ▶ Determine Training Approach  
  - Specify program design  
  - Specify training settings  
  ▶ Develop Learning Objectives  
  ▶ Develop Performance Measures  
  - Skill assessment  
  - Attitude assessment  
  - Knowledge assessment  
  ▶ Develop Training Program Specifications  
  - Facility needs  
  - Equipment needs  
  - Staffing needs | ▶ Specification of Program Design and Training Settings  
  ▶ Sequenced Objectives Testing Specifications and Measures for Knowledge, Skill, and Attitude Assessment  
  ▶ Description of Facility, Equipment, Staffing, and other Program Specifications | Curriculum Design Specifications |
| **Development** | ▶ Develop Competency Profile  
  ▶ Develop Trainee Materials  
  ▶ Develop Supportive Media  
  ▶ Develop Teacher/Student Learning Guide(s)  
  ▶ Pilot-Test/Revise Materials | ▶ Competency Profile  
  ▶ Modules or Learning Guides  
  ▶ Teacher/Student Learning Guide(s)  
  ▶ Supportive Media  
  ▶ Field Tested Materials | Instructional Materials  
  - Competency Profile  
  - Teacher’s Guide  
  - Learning Guides  
  - Modules  
  - Audiovisual Materials |
| **Implementation** | ▶ Implement Training Plan  
  - Recruit/Select trainees  
  - Orient and train staff  
  - Secure needed facilities  
  ▶ Conduct Training  
  ▶ Conduct Formative Evaluation  
  ▶ Document Training Results | ▶ Students/Trainees  
  ▶ Appropriate Facilities  
  ▶ Training Staff  
  ▶ Trained Students/Workers  
  ▶ Program Improvement Data  
  ▶ Trainee Achievement Data | Competent Trainees/Workers  
  Training Program Achievement and Improvement Report |
Table 4  Student Learning Guide FORM according to the SCID

<table>
<thead>
<tr>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>▶ Conduct Summative Evaluation</td>
</tr>
<tr>
<td>▶ Summative Data</td>
</tr>
<tr>
<td>▶ Program Evaluation and Improvement Plan</td>
</tr>
<tr>
<td>▶ Process data collection</td>
</tr>
<tr>
<td>▶ Process feedback</td>
</tr>
<tr>
<td>▶ Description of Program</td>
</tr>
<tr>
<td>▶ Product data collection</td>
</tr>
<tr>
<td>▶ Product feedback</td>
</tr>
<tr>
<td>Improvements Needed</td>
</tr>
<tr>
<td>▶ Cost data assembled</td>
</tr>
<tr>
<td>▶ Follow-up data</td>
</tr>
<tr>
<td>▶ Program cost data</td>
</tr>
<tr>
<td>▶ Collect follow-up data</td>
</tr>
<tr>
<td>▶ Interpret data</td>
</tr>
<tr>
<td>▶ Program improvement</td>
</tr>
<tr>
<td>▶ Analyze Information Collected</td>
</tr>
<tr>
<td>▶ Initiate Corrective Actions</td>
</tr>
<tr>
<td>Plan with Specific</td>
</tr>
<tr>
<td>Recommendations</td>
</tr>
</tbody>
</table>

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2) Robert E. Norton(1997). DACUM HANDBOOK, Center on Education and Training for Employment College of Education The Ohio State University 1900 Kenny Road Columbus, Ohio 43210.
3) Robert E. Norton(1999). SCID HANDBOOK, Center on Education and Training for Employment College of Education The Ohio State University 1900 Kenny Road Columbus, Ohio 43210-1090.
1. Introduction

Technology education means different things to different educators, from primary education to higher education, from general education to vocational education. For example, in terms of general education, International Technology Education Association (ITEA), a professional association for technology education teachers, defines “technology education” as “problem-based learning utilizing math, science and technology principles.” ITEA argues that technological studies involve: (1) designing, developing, and utilizing technological systems; (2) open-ended, problem-based design activities; (3) cognitive, manipulative, and effective learning strategies; (4) applying technological knowledge and processes to real world experiences using up-to-date resources; and (5) working individually as well as in a team to solve problems. For another instance, the Accreditation Board for Engineering and Technology (ABET) is the recognized accreditor for college and university programs in applied science, computing, engineering, and technology, and the Technology Accreditation Commission (TAC) is one of four accreditation commissions within ABET. TAC develops criteria for accrediting 23 specific engineering technology programs, such as bioengineering technology, information engineering technology and manufacturing engineering technology. That is to say, ITEA’s technology education provides students with an opportunity to explore a wide range of technology related areas without a focus on specific employment skills, while ABET’s technology education provides students with specific job skills leading to employment.

Therefore, technology education is a study of technology, which facilitates students to learn the knowledge and skills needed to function in a technological society. As a study, technology education in the span of human life should be
holistic and ongoing. In other words, technology education should be considered as a lifelong learning process, which encompasses learning throughout the life cycle, from birth to grave and in different learning environments, formal, non-formal and informal ⁴) (see Table 1).

**Table 1 A rough comparison of formal, non-formal and informal learning**

<table>
<thead>
<tr>
<th>Learning Context</th>
<th>Formal learning</th>
<th>Non-formal learning</th>
<th>Informal learning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning Context</td>
<td>Structured</td>
<td>Semi-structured</td>
<td>Unstructured</td>
</tr>
<tr>
<td>Learner’s Perspective</td>
<td>Intentional</td>
<td>Intentional</td>
<td>Non-intentional</td>
</tr>
</tbody>
</table>

A model is a generalized or hypothetical description, often based on an analogy and used in analyzing or explaining something ⁵). Technology education needs a lifelong learning model to promote the analysis and explanation of technology education. The purpose of this paper is to propose a lifelong model of technology education.

2. A Lifelong Technology Education Model Proposed

The model is proposed as shown in Figure 1, which has five stages of development ⁶). This model assumes that everyone in most countries/regions should have opportunities to learn about technology in every stage. Learning in the first three stages mainly happens in schools, while learning in the last two stages mainly happens after entering workplace. Learning in schools may be taught with activities that are infused in other classes or as a separate course. Learning after entering workplace may lean to non-formal and informal forms. Educators at each of the following five stages of development should focus on their own special outcomes, and reach out for partnerships with educators at other levels of this lifelong learning process. There is room for technology education in some way everywhere in every educational system.

2.1 Stage I-AWARENESS

In primary grades, students should be aware of the existence of technology in various facets of daily life. At this first stage the focus is on discovering the basics of tools, materials, career opportunities related to technology. Motivation to learn about technology and a sense of praxis are the special outcomes at this
stage of the lifelong learning model.

2.2 Stage II-LITERACY

The students in junior high and senior high schools will learn to effectively interact with technology at this stage. They gain necessary and basic technological skills, known as technological literacy, at this stage and apply technological literacy in daily life. The outcome is for all students to become technological literates.

2.3 Stage III-SPECIALIZATION

At this stage, students can take time to identify their own career path and gain a greater depth and breadth of knowledge and skills than the previous stages. This stage may take place in vocational high schools/programs, two-year colleges, training centers, and colleges as well as universities. The outcome is for students to learn how to be successful in the job markets related to technology.

2.4 Stage IV-APPLICATIONS

After entering workplace, youngsters will have opportunities to fully apply what he learned about technology in work, family and leisure. They also have time to gain job experience and/or further education regarding technology. Youngsters become a smart consumer, a productive worker and a ongoing learner in a technological society is the special outcome at this stage.

2.5 Stage V-GROWTH

At this stage, adults effectively solve technological problems and continuously enhance technological competencies. A variety of education and training programs are widely available to help them to keep growth in technological literacy and competencies. The outcome is for adults to timely update and upgrade their technological literacy and competencies.
3. Taiwan as an Example to Use the Proposed Model

The world’s educational systems considerably differ. According to the International Standard Classification of Education, known as ISCED97 and developed by UNESCO in November 1997, a national education system can be classified and coded as follows:

0- Pre-primary education
1- Primary education/First stage of basic education
2- Lower secondary education/Second stage of basic education
3- (Upper) secondary education
4- Post-secondary non tertiary education
5- First stage of tertiary education (not leading directly to an advanced research qualification)
6- Second stage of tertiary education (leading to an advanced research qualification)

Normally, the Stage I in the proposed model takes place in Codes 0 and 1, Stage II in Codes 2 and 3, Stage III from Codes 3 to 6, Stages IV and V might link to Codes 4, 5 and 6.

The educational system in Taiwan is shown as Figure 2. It can serve as an
example to use the model proposed above. The present education structure in Taiwan supports 22 years of formal study. Completion times are flexible, depending upon the needs of the students. Normally, the entire process requires 2 years of preschool education, 6 years of elementary school, 3 years of junior high, 3 years of senior high school, 4-7 years of college or university, 1-4 years of a master’s degree program, and 2-7 years of a doctoral degree program. The nine-year compulsory education in Taiwan is comprised of elementary and junior high schooling 8).

![Figure 2: The educational system in Taiwan](image)

Taiwanese people may learn about technology in the five stages in the lifelong learning process (see Figure 1) as follows:

**3.1 Stage I-AWARENESS**

According to national curriculum promulgated by Ministry of Education (MOE), technology education in elementary schools is integrated with science education. The key learning area (KLA) embracing science and technology education is called “natural science and living technology (NS&LT).” The
purpose of this KLA is mainly to provide students with scientific and technological awareness education.

3.2 Stage II-LITERACY

In Taiwan, all students in junior high and senior high schools are required to take technology education courses for becoming technological literates. At the junior high level, technology education is mainly offered by the KLA “NS&LT,” while at the senior high level, living technology (LT) is an independent course.

3.3 Stage III-SPECIALIZATION

Career-oriented students in vocational high schools/programs, junior colleges of technology, colleges and universities can learn technological competencies for further employment and studies. Specific programs widely include agriculture, industry, business, maritime, engineering, medicine, nursing, home economics, etc.

3.4 Stage IV-APPLICATIONS

Once graduating from vocational high schools/programs, training centers, junior colleges of technology, colleges or universities, students may choose to enter workplace. After entering workplace, they can fully apply what he learned about technology in work, family and leisure. They also have time to gain job experience and/or further education with respect to technology.

3.5 Stage V-GROWTH

In order to keep their own technological literacy and competencies updated and upgraded, adults in/out of workplace can keep learning about technology in formal, non-formal or informal learning environments.

In addition, the technology educators in Taiwan like to categorize the technology education in formal education institutions into the following two types: (1) technological literacy education, and (2) technological specialty education (see Figure 3). In Figure 3, when a student goes up to advanced educational institutions, he/she receives deeper technological literacy education and more technological specialty education. Upper secondary education institution is a confluence of technological literacy and specialty education. For example, senior high schools mainly offer technological literacy education while vocational high schools technological specialty education.
4. Two Main Features of the Proposed Model

In conclusion, the lifelong technology education model as shown in Figure 1 is universal. It at least has the following two features:

4.1 All-in-one

All possible technology education opportunities for school pupils, college students, and adult learners are embraced in the model. In addition, both general and specialized technology education programs are included in the model. That is, the model is all-in-one.

4.2 One-for-All

The model is proposed to serve as a conceptual or re-conceptualized tool/framework to analyze and explain all technology education in most countries or regions. That is, it is one-for-all.

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1. Introduction and Background

Several studies conducted by the European Union (e.g., Eurostat 2004, Implementation of “education & training 2010” work programme) demonstrate that women and girls are continuously dramatically underrepresented in science and technological education, areas, and jobs. The concern of this problem brought 16 universities and research institutes from 11 European Union countries together under UPDATE-project which is funded by EU for three years from the beginning of 2007 till the end of 2009. Compared to many other projects that have tried to involve girls in technology, the UPDATE approach includes a strong focus on early childhood and primary education, phases in which the attitudes are often formed. From this understanding, it is far too late to start to try rising the girls’ interest at only at secondary or later stages.

We are convinced that with new, improved technology education practices it is possible to make technology more attractive for young people, promote their interest, and encourage their critical and creative ways of thinking.

The UPDATE project’s aim is threefold: 1) to examine why girls drop out from technology education at different stages of their education, and 2) to create new ways and educational methods to make the image of technology and technological careers more attractive for both boys and girls, and 3) to promote,
encourage and mobilise especially girls and young women for engineering and technology both as a career, and as active users of modern technology. This study tends to find information mainly to the first question.

A framework for analysing the different curricula in different EU-countries was created in co-operation of several EU-partners and this tool was used in analyzing the curricula of several countries. In addition to curriculum descriptions a content analyses of National Framework Curriculum in Finland and curricula of four municipalities were carried out by using Virtanen’s (2008) framework of technology education. The framework was created for deeper and more analytical curriculum analyses. The analysis was about technological contents and how they are taught within different subject areas in general education at grades 1.-6. (ages 7 to 12). Particularly, the aim was to find out in which subjects technological innovation processes can be found.

The two authors of this article Professor Hidetoshi Miyakawa and Doctor Aki Rasinen have a long experience in international development co-operation. In Japan, Aichi University of Education has been hosting a JICA (Japan International Co-operation Agency affiliated to Ministry of Foreign Affairs) training course for developing countries around the world since 1999. Aki Rasinen has been working in African countries, mainly Zambia, from late 70’s till late 90’s. Professor Hidetoshi Miyakawa was funded by Finland Academy and Japan Science Promotion Association to conduct a research in co-operation with the University of Jyväskylä in Fiscal year of 2008. Within this co-operation learning of creativity during technology lessons and comparative study will be carried out. This paper would, when published, be a useful contribution for not only Finland but also other countries and organizations such as JICA training course. With this experience we believe that the study presented below will contribute to the planning of technology programmes in any country.

2. Analysis of Technology Education in the Curricula of Five EU-Countries

This analysis concentrated on the curricula of six to twelve year old school children (primary, middle, junior secondary). Through analysing the curricula
of different countries we tried to find building materials for a holistic and
gender equal technology education curriculum. A framework for analysing the
curricula in different EU-countries was created in co-operation of several EU-
partners under UPDATE-project. Following seven aspects were taken into
account:

1 Characteristics of the school system
2 Characteristics of the general curriculum
3 Position and status of technology education in the curriculum
4 Aims of technology education
5 Pedagogical means and methods for technology education
6 Main themes and structure of curriculum content
7 Characteristics of the teachers in charge of technology education

The central aim was to discover weak points and strengths of each country’s
curriculum. The viewpoint was to find out gender-related, encouraging or
discouraging reasons why girls drop out of technology and loose their interest
in technological careers. The curriculum of Austria, Estonia, Finland, France
and Germany is dealt with. The analysis is based on the presentations of the
above mentioned country-members in an UPDATE-project meeting held in
Aix-en-Provence on the 22nd of May 2008, which, in turn were based on the
curricula of each country.

Characteristics of the School System

In Austria, Estonia, Finland and France and Germany all citizens must go
through an eight/nine year basic education. In Germany all 16 states decide
about their own curriculum. The age of starting schooling varies from 6 (3) to 7
years and lasts to the age of 15/16. Basic schooling lasts from 8 (or 12) years in
France to 9 years in Austria, Estonia and Finland and 9/10 years in Germany. In
Austria and Germany there is a four year primary school education for all.
After that schooling branches to different types of secondary education.
Whereas, in Estonia, Finland and France (with different key stages) the basic
education system is pretty similar to most of the pupils.
**Characteristics of the General Curriculum**

In Germany Ministry of Education has published some directives for the different states to follow. These are very broadly framed and the curricula of the states differ from each other. In Austria, Estonia, Finland and France a national curriculum is implemented. In Austria and Finland the nature of the curriculum is of a framework. The municipalities and schools draw their own curriculum following the guidelines of the national framework. In Austria the framework curriculum is more of a “lehrplan” -type (very exact stating the objectives, educational goals, content and giving advice how to teach), whereas in Finland the framework curriculum is of more general nature. In Estonia a national curriculum is followed but the schools compile their own curriculum. In France a compulsory national programme is followed.

**Position and Status of Technology Education in the Curriculum**

In the five countries analysed a subject called technology does not exist. However, technology is studied in all the five countries. In most of the countries technological activities take place during craft lessons. In Austria technical education, in Estonia, craft and technology education, in Finland technical work is studied. In France technological studies take place during science lessons at primary level and in the middle schools something in between science and technics is studied. In Germany technology is studied in primary (first four years) during social studies and handicrafts lessons and in secondary (mainly in secondary general schools and comprehensive schools by boys, less at intermediate and grammar schools) during physics, chemistry, handicrafts, technical drawing, computer science and work theory lessons. In all countries technology education takes place during primary education. France is the only one where boys and girls equally study technological contents also in the middle school. In all other countries some kind of differentiation takes place at later stages of basic education. In Austria and Germany the secondary education differentiates to two or three parallel school systems, whereas, in Estonia, Finland and France the basic school system is comprehensive to all pupils. Also in Estonia and Finland craft is divided to technical and textile craft and all pupils are not always entitled to study both. In
the Finnish curriculum Human Being and Technology and is one of the cross-curricular themes which should be considered in all subjects.

Aims of Technology Education

In all five countries technology education is part of general education. It is no more a pre-vocational subject than any other school subject, although, one of the aims is to give some ideas of technological studies as future studies. The aims are described on one hand to learn substance (issue related) know-how, such as: construction, manufacturing, technical processes, electricity etc. and on the other hand, see the importance of technology in our daily lives, learning how to deal with technology in a responsible and ethical way, to take one’s stand on development of technology, develop the readiness of pupils to live and to work in the world of today and in the quickly changing technological world of tomorrow. The aims are surprisingly similar in all five countries. However, there are no standards for technology education in any of the countries.

Pedagogical Means and Methods for Technology Education

The pedagogical means and methods are very similar in all five countries. Hands-on activities are emphasized in all curricula. In Estonia the curriculum states that practical activities should cover 2/3 of the total study time. Such learning methods as observation, exploration, experimenting, discovery, analysis, problem solving, design, manufacture and innovation are expressed. However, teachers have freedom to choose any methods convenient to the learning session at hand according to their own wish. Also both individual work and co-operative learning methods are encouraged. In Estonia a handbook for teachers is available and in Austria one book for junior secondary school pupils is available.

Main Themes and Structure of Curriculum Content

Technology is studied in special class rooms at least at secondary level. Themes and structure of curriculum content in the five countries resembles each other in many ways. In Austria architecture is one of the sub-domains of study. This area of education is not mentioned in the curriculum of other countries. Whereas, energy, transport, construction, design, process, communication, manufacturing,
transmitting power are common themes in the curriculum of the five countries. The curriculum of Finland emphasizes the ethical and environmental concerns in technology education. Different materials, such as paper, textiles, plastics, wood, metal, electronic components etc. are mentioned in many curricula. Tools, equipment, machines, computers, computer operated machines should be used and studied.

Characteristics of the Teachers in Charge of Technology Education

Generally speaking class-teachers (who may be specialised in teaching technology) teach technology classes in primary schools. In middle/junior secondary schools either class-teachers or specialised teachers take care of the lessons. Most of the primary sector teachers are female (at least in Finland and Germany). Some teachers have very little if any training in teaching technology. Some in-service training is available in different countries but teachers do not have to enrol if they are not interested. In secondary technology can be taught by subject teachers who represent various school subject, mainly craft (technical or textile), home-economics or technical work.

Strengths and Weaknesses

Technology education is not a stand alone subject in any of the five countries. In Austria technical education and in Finland technical work (as a domain of craft) is studied. On the top of this the Finnish National Framework Curriculum introduces a cross-curriculum theme “Human Being and Technology”. In Estonia technological contents are studied mainly during craft. Craft is divided in handicraft (which is studied from grade 1. to 3.) and home-economics (studied from grade 4. to 9.) and craft and technology education (from 4. to 9.). In France studies of technology can be described to be somewhere in between science and technics. Whilst in Germany technological contents are studied at primary level (grade 1. to 4.) during social studies and craft lessons. At middle/secondary level technology is studied more at secondary general schools and comprehensive schools and less at intermediate and grammar schools. It is studied often in combination with science subjects. As a conclusion it could be claimed that as technology education is not a subject of its’ own, technological contents can
easily be ignored and for instance science and craft will be taught from “non-technological” starting points. On the other hand if the teachers have training in technology education and they are motivated to implement technological contents the desired objectives can be achieved.

Because technology education is not a stand alone subject and the courses where it could be studied are often optional there is no systematic education on this field for everyone. One of the problems is the differentiation of craft subject to technical and textile crafts. By choosing one study domain of the two the pupils may exclude technological studies from their curriculum completely. Teachers particularly in primary section are often women who are not trained to teach technology. Therefore, they tend not to teach contents of the subject. Also the freedom of the teachers to plan their own lessons may cause neglecting technical studies.

Only in Austria and Estonia textbooks are available. For teachers who have got no education or very little education in technology it is difficult to teach contents that are not familiar, particularly, if there is no easy access to resource materials. Also lack of in-service education in technology affects in a negative manner. An organized in-service education system would probably assist teachers to get rid of their prejudice and motivate them to start teaching also technical contents.

Traditionally technology has been a male dominated field. This has also reflected to the school curriculum and teacher education. By moving from “boys friendly” contents to “girls and boys friendly” contents both sexes could be motivated to study technology.

3. How to Analyze the Curriculum - A Finnish Example

The analysis above is of more general nature, whereas, in the following a deeper analysis is introduced. The Finnish National Framework Curriculum was used when creating this framework for more exact analysis. The higher levels of learning i.e. invention, problem solving and creative thinking were of special interest. This model can, naturally, be used in analyzing the curriculum
of any country. Finland has a basic comprehensive education system for all pupils at grades 1.-9. (ages 7-15). Compulsory education consists of elementary level grades 1.-6. and lower secondary level grades 7.-9. Schools write their own curricula based on the National Framework Curriculum 2004, which has been formulated on the basis of the concept of learning, described in the general part of the curriculum. National framework curriculum describes what the main objectives and core contents are in every school subject and cross-curricular themes. There are also some descriptions of methods. National curriculum describes guidelines for cross-curricular themes, which should have the central emphasis of the educational and teaching work. Some subjects are taught only for grades 1.-4. and for 5.-9. and some only for 7.-9.

Compulsory subjects at grades 1.-6.:  
- Mother tongue and literature  
- Foreign language (from grade 3.)  
- Mathematics  
- Environmental and natural studies (grades 1.-4.)  
- Biology and geography (from grade 5. as a subject area of its own)  
- Physics and chemistry (from grade 5. as a subject area of its own)  
- Religion  
- History (from grade 5.)  
- Music  
- Visual arts  
- Crafts  
- Physical education

Cross-curricular themes at grades 1.-6. Their objectives and contents are incorporated in to numerous subjects.  
1. Growth as a person  
2. Cultural identity and internationalism  
3. Media skills and communication  
4. Participatory citizenship and entrepreneurship  
5. Responsibility for the environment, well-being, and a sustainable future
6. Safety and traffic
7. Human being and technology

**History of Technology Education**

In Finland, craft as a subject has been divided between technical work (boys’ craft) and textile work (girls’ craft) for a long time. In the National curriculum 1970, it was emphasised that the division between girls and boys should no longer be done, but both should study the same contents from grade one to three, then choose one of the subject areas for grades four to seven. However, boys mainly went for technical craft classes and girls for textile craft classes. Since the 1970 curriculum document there hasn’t been national curriculum, but documents after 1970 curriculum have been framework curricula and municipalities and schools have planned their own curricula following the National Curriculum Framework. In the Framework Curriculum for Comprehensive Schools 1985 equality at schools was introduced as one of the six general objectives, but it was left to the schools to decide how to organize craft education. In practice, many schools continued to differentiate pupils after grade three in either textile or technical work, according to gender. In the Framework Curriculum for Comprehensive Schools 1994 crafts, technical work and textile work formed an entity which was meant for pupils regardless of gender. Also for the first time technology was clearly mentioned in the general objectives of the curriculum. However, in addition to having partly common craft education for boys and girls, the document allowed the schools to emphasize one of the two craft domains and nothing changed in practice. (Rasinen, Ikonen & Rissanen, 2006, 450-452.)

The National Framework Curriculum, 2004 states that in crafts studies:

**Grades 1.-4.**: The instruction is implemented with the same content for all pupils, and consist technical and textile work.

**Grades 5.-9**: The instruction consists of technical- and textile contents. In addition, pupils may be given a chance, in their crafts studies, to emphasize either technical or textile work according to their interests and inclinations.
The history of craft education still lives strongly and division between boys and girls goes on contrary to the guidelines of the national framework curriculum. See Figure 1.

![Figure 1 History of craft education in schools. (see Kantola 1997, 48)](image)

Still today technology education is not a stand alone subject in Finland, but the latest national curriculum 2004 contains technology education. One of the seven cross-curricular themes is *Human being and technology*. Some objectives and contents of science and many objectives and contents of crafts (particularly in technical work domain) have many similarities with the objectives and contents of this cross-curriculum theme.

### 4. Framework for Content Analysis

In addition to curriculum description and analysis of the seven aspects introduced before, a content analysis of National Framework Curriculum 2004 of Finland was carried out by using Virtanen’s (2008) framework of technology education. The framework was created for deeper and more analytical curriculum analyses. Figure 2. “Framework for curriculum analysis” illustrates the *contents of technology education and progress of learning process combined*. Framework is based on Parikka’s and Rasinen’s (1994) description of concept of technology in teaching and Parikka’s (1998) cube model of defining the concept of technology. In addition to these two models, concepts are set out as levels 1-3 to create a hierarchy for
multidimensional concept of technology and to describe the development of pupils’ technological literacy and competence step by step. The levels describe the mental process of pupils’ understanding and the level of technological competence. Noticeable aspect is that technological processes are not to be interpreted as one way processes. When studying different contents of technology or even during the same process, pupils may sometimes have to get back to basics to level 1.

LEVEL 1: Information: pupils are given basic information about phenomena behind science and technology, usefulness of technology and about various materials and tools.

LEVEL 2: Identification and expression: pupils can recall items of technological knowledge or phenomena, identify and explain their usefulness in everyday life or implement them in simple situations.

LEVEL 3: Application: in a given formalized context, in order to solve a problem pupils are able to apply their knowledge and tools in practice and combine them to create innovative solutions.

Figure 2 Framework for curriculum analysis. Student’s mental process of understanding and the level of technological competence (Virtanen 2008)
Technological innovation process

Technological innovation process comprises many conceptual and functional levels; knowledge of materials and tools, know how, understanding of concepts of technology and application. It is important that knowledge which one has is applied or put into practise in an innovative, “creatively new” way. Innovation process is associated with brainstorming, problem solving, innovativeness, inventiveness, design, modelling, evaluation, experimental approaches and also creativity, aesthetical and ethical aspects. The aim of the activity is that awareness raising, learning and design processes are integrated to enable application and create innovative solutions. In technology education learning by doing method has a central role in innovative problem solving processes.

5. Analysis of Subjects and Cross-Curricular Themes

The analysis concentrated on technological contents and how they are taught within different subject areas in a general education at grades 1.-6. (ages 7 to 12) in National Framework Curriculum 2004. Particularly, the aim was to find out in which subjects technological innovation processes can be found and how instruction could be organized in schools in point of view of technology education. The analysis evidenced that the subjects in which innovation processes are well realized are the following: crafts (grades 1.-4.), crafts (grades 5.-9., particularly in technical work), visual arts.

In the following it is presented and discussed which subjects are listed as innovation processes well realised subjects and what contents in point of view of technology education can be found.

Crafts

In crafts (grades 1.-4.) objectives are that pupils’ learn to master the entire crafts process: brainstorming, design, modelling, making, evaluating. Instruction is implemented through projects corresponding to the pupils’ stage of development, and uses experimentation, investigation, and invention. The instructional tasks are to develop creativity, problem solving skills, and understanding of everyday technological phenomena, and aesthetic, technical,
and psychomotor skills. (National Framework Curriculum for Basic Education 2004, 240.) All these objectives are parts of the technological innovation process, as long as pupils are encouraged to make creative innovative solutions and working approaches are learner-centred.

General objectives in crafts (grades 5.-9.) support also the objectives of technology education by deepening pupils’ knowledge and skills of crafts, so they are able to choose materials, craft techniques, and tools appropriately at the different phases of the crafts process more independently than before. Pupils are encouraged to learn to design and produce high-quality, aesthetically pleasing products suited to their purposes, and to give consideration when, working, to ethical, and economic values. Pupils are encouraged to find creative solutions to the problems they perceive, using various sources of information as an aid. (National Framework Curriculum for Basic Education 2004, 241-242.) These above mentioned objectives are also parts of the technological innovation process, as long as pupils are encouraged to make creative innovative solutions and working approaches are learner-centred.

If pupils have to choose one subject area for grades 5.-9., technical work or textile work, only technical work can be seen as supporting technology education by encouraging pupils to creative use of various materials and techniques for different purposes, when studying structures, technological concepts and systems, applications and searching creative solutions to the problems their perceive. If pupils have to exclude technical work after grade four they will not have possibilities to go on technology education from this point of view.

**Visual arts**

In visual arts pupils are encouraged to develop their own imagination by making observations and inventions. The objectives of the instruction are to develop the imagination and promote the pupils’ skills in creative problem solving and investigative learning. (National Framework Curriculum for Basic Education 2004, 241-242.) Learning process is similar to technological
innovation process; planning, making a sketch, completing a work and evaluation. However, the activity in visual arts can’t always be about technological contents, but meaningful and integrative projects between technology educational themes and visual arts would increase holistic teaching.

**Cross-curricular themes**

In the cross-curricular theme *Human Being and Technology* pupils are guided to understand the individual’s relationship to technology, and to see the importance of technology in our everyday life. Education has to offer a fundamental knowledge of technology, its development and its impacts. Pupils learn to understand technology and creative problem solving skills by making technology. These objectives are parts of the technological innovation process, as long as pupils are encouraged to make creative innovative solutions and working approaches are learner-centred hands on activities.

In the cross-curricular theme *Participatory Citizenship* and entrepreneurship pupils are encouraged to act innovatively and perseveringly in achieving a goal, and to assess their own personal actions and their impacts. However, the activity in entrepreneurship education can’t always be about technological contents, but meaningful and integrative projects between technology education and entrepreneurship education would be naturally combined.

**Discussion**

The national curriculum has been formulated on the basis of concept of learning as an individual and communal process of building knowledge and skills (National Framework Curriculum for Basic Education 2004, 16). Municipalities and schools write out their own curriculum where innovative approaches may be pointed more out than in the national framework curriculum. It is important to realize that the previously described analysis is based on the National Framework Curriculum 2004.

A tentative analysis, using the same framework, of four municipal curricula shows that technology is studied to some extent on top of crafts and visual arts
also in history, environmental and natural studies, physics and chemistry. The municipal curricula are more detailed and schools write their own curriculum emphasizing the local culture. Therefore, technology education has been referred to also in subject areas where the national framework curriculum does not state out objectives and contents of technology. One must note that although technology is mentioned, innovation processes are not described in all subjects. Next step would be to find out in a more comprehensive manner how national guidelines are realized in the municipal or school curricula and finally find out what is the reality in the classrooms.

The analysis shows that there is not much education for innovativeness in the Finnish National Framework Curriculum. Only through crafts, mainly technical work and visual arts pupils are encouraged to learn these important skills. This makes it even more important for teachers to put emphasis on these very disciplines. There is no doubt that innovative skills are very important for the future life of the children. The demands of the working life are rapidly changing towards this direction.

6. Challenges of Technology Education

Based on the content analysis described previously (or meta-analysis) of the curricula of five counties which give general information, and on of the more detailed and thorough analysis of the Finnish national framework curriculum, it could be claimed that technology education as such does not exist in the curricula of these countries. Technology is mainly studied during craft lessons. However, contents of these lessons can be quite traditional and do not educate children to meet the technology of today and particularly of the future. One of the problems is that pupils are forced to choose between technical craft and textile craft. This means excluding one part of technological education completely. The first step to take would be allowing all children to have equal craft education. This would also mean re-thinking of the learning contents to be gender neutral or to suit both sexes.
There would be at least three ways of organizing teaching in the future. One way would be developing craft education towards modern technology. Another way would be (and what the Finnish National Framework Curriculum encourages) to find technological contents in different subject areas and try to integrate different subjects from this point of view. Probably the most effective way to guarantee technology teaching would be to develop a new school subject. Together with this a massive re-organisation of teacher education (pre- and in-service), development of learning materials and careful analysis of learning contents should take place.

It is also important to find out what kind of activities or which topics best activate pupils to study technology, especially girls. One goal of the UPDATE -project is to create best practices which encourage pupils for inventiveness, creativity and technological innovative problem solving.

Concept of technology and technology education differs between countries and cultures. We find it important that technology education should be developed considering always the culture of the country concerned. One can never be too critical in this respect. It is not advisable to transfer ideas of how or what to teach directly, but tools to develop technology education may be discovered. Finally, we hope that the analyses in this article will give ideas and prospects for analysing and developing technology education in any country.

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**1. Introduction**

Toward better life style, much more energy has been needed due to vast increase of automobiles, electrical appliances and information equipment. This brings the serious phenomenon of ‘global warming’ that is the most important problem we encounter. Assignment for decrease of CO\(_2\) in Kyoto Protocol is one of trials to this problem[1]. However, it is the fact that emission of CO\(_2\) is increasing year by year. Especially, emission caused by transportation such as automobiles with combustion engine increases a lot these days. Environmentally friendly cars with energy-saving technologies have been developed to cope with this problem. Systematic approach should be considered as the most effective way. Therefore, education regarding energy and environment in primary and secondary school plays vital role for energy-environmental issues[2]. It is important for students to study using hands-on experience from the viewpoint of energy consumption. Curriculum and teaching material with contents of current and interesting topic should be required. However, it is hard to find teaching practice with experience which relates to energy saving technology for automobiles at secondary school in Japan.

In this paper, we have developed educational electric vehicle by which students are able to ride on and experience energy saving technology of PWM (pulse width modulation) speed control and regenerative braking system. By this vehicle, students can learn basic concept of interchangeable between electrical energy and kinetic one. We implemented a class concerning energy...
saving technology at secondary school. After class, this course was evaluated by questionnaires and interview.

2. Control Circuit with Bi-directional Energy Flow

Electric vehicle and Hybrid vehicle have the function of regenerative braking system as energy saving technology[3]. We have developed a simple control circuit for a class in secondary school by which both speed control and regenerative braking system can be realized.
Figure 1 shows the control circuit for electric vehicle (EV) of teaching material. In this figure, FET (field effect transistor) switch Sw1 and Sw2 are driven alternately. It is prohibited that Sw1 and Sw2 turn on at the same time, or both FET switch could be destroyed due to short circuit. Figure 2 shows gate to source voltage for Sw1 and Sw2, respectively. Motor is modeled as series connection of L and R, where R represents kinetic energy and L coil inside motor. Speed control can be realized using PWM by this switched-mode circuit with high efficiency of power transfer.

The circuit shown in Fig.1 operates as step down DC to DC converter which is shown in Fig.3. The output voltage in this figure is expressed as \( DEB(D=\frac{Ton}{Ts}) \) where Ton shows the period during Sw ON and Ts during one cycle. Thus, output voltage is controlled by varying Ton. In Fig.1, the voltage across R is expressed as \( DEB(D=\frac{Ton}{Ts}) \). Therefore, speed of motor can be controlled by varying Ton.

Figure 4 shows the control circuit at regenerative braking period. This mode occurs when duty ratio of D (Ton/Ts) decreases abruptly in the state of motor rotating. Motor tends to rotate due to inertia, and it plays a role of electrical power generator. EM shows this generated voltage. The current IB from battery to motor is shown in Fig.5. After duty ratio D (Ton/Ts) decreases abruptly at the time depicted by “Brake ON” in Fig.5, the current IB begins to decrease. Moreover, the current goes into negative region where electrical energy generated by motor is transferred to battery, and this acts as a brake without loss. Thus, the energy at braking period can be charged to battery, and this energy is reused to accelerate EV again. The circuit shown in Fig.4 operates as step-up DC to DC converter while motor is generating electrical energy, and this energy flows from motor to battery EB. The generated voltage \( EM \) is converted to \( EM/D \) at input stage as shown in Fig.6. D is duty ratio of Ton/Ts where Ton shows ON period of FET Sw1. The electrical energy is transferred from motor to battery under the condition of \( EB>EM/D \).

3. Developed Electric Vehicle

We have developed a chassis, controller and measure of electrical energy for EV that is used at a class in secondary school. Students are able to get on this
EV, drive it by themselves, experience abovementioned regenerative braking system, and measure the regenerative energy in joule.

Figure 7 shows the chassis of EV which is made of wood. The reason why wood is chosen is that it is easy for students to process wood and the price is reasonable. Table 1 demonstrates the specifications of this EV.

Moreover, we developed measurement system for regenerative electrical

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**Fig.7 Chassis of Electric Vehicle.**

**Fig.8. Measure for regenerative energy.**

**Fig.9 Block diagram of Electric Vehicle.**

**Fig.10 Controller for Electric Vehicle.**

**Fig.11 Basic experiment kit.**

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**Table 1. Specifications of Electric Vehicle**

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Size</td>
<td>1290mmX715mmX715mm</td>
</tr>
<tr>
<td>Weight</td>
<td>28-kg</td>
</tr>
<tr>
<td>Material of chassis</td>
<td>Wood</td>
</tr>
<tr>
<td>Motor</td>
<td>DC24V/100W-X2</td>
</tr>
<tr>
<td>Battery</td>
<td>12V-3.5Ah-X2</td>
</tr>
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energy at braking period using by micro-controller (PIC-877). This measure for energy is shown in Fig.8 where the regenerative energy is 435.5[J] and the resistor is used to monitor the current. Students understand empirically that the more frequent braking action, the more accumulated regenerative energy by using this measure.

The block diagram of EV is shown in Fig.9, where bi-directional PWM converter has been explained in Figs.1 and 4, M1 and M2 are motors, and Controller is shown in Fig.10. This Controller is very common among secondary students in Japan, nowadays. This is the important reason why we adopted this kind of controller. Moreover, we added a dial for speed control to this controller.

4. Basic Experiment Kit for Regenerative Brake

We also developed basic experiment kit of energy saving technology for secondary school students.

The circuit diagram of this kit and its photos are shown in Figs.11, 12, and 13. EDLC in Fig.13 stands for Electrical Double Layer Capacitor with capacitance of 1F(20V). This kind of capacitor has been used as substitution for battery, recently.

The contents of class using this kit are as follows:

<EXP.1> **To experience inertia of motor**
Motor begins to rotate after student turns the switch Sw to battery side A. Then,
students observe that it takes a time due to inertia till motor stops, after turning the switch to neutral position B.

**<EXP.2> To experience role of motor as generator**
Student turns the switch Sw from battery side A to load side C to observe what happens. Motor stops quickly compared to abovementioned neutral side in **<EXP.1>**, when resistor is connected as load. Next, students try this experiment to various loads such as bulbs, buzzer and small motor shown in Fig.13. Eventually, they can induce that motor operates as power generator while it is rotating due to inertia and that energy can be converted to different kind of forms like kinetic, electricity, light and thermal.

**<EXP.3> To experience energy stored in EDLC**
It is impossible to reuse energy, once kinetic energy of motor is changed into light or thermal energy. This time, EDLC is used as load in Fig.11. The kinetic energy of motor is accumulated in EDLC as form of electrical energy. Students experience that much more energy is stored as the switching cycle from A to C increases in Fig.11 by measuring the voltage across EDLC. Next, they observe what happens after output of EDLC is connected to loads such as small motor and buzzer. This experiment demonstrates that EDLC charged by kinetic energy of motor plays a role of battery and it is possible to reuse the energy.

**5. Implementation and Evaluation**
We implemented the class using abovementioned teaching material at secondary school and evaluated educational effectiveness. Twenty students of second grade took this class. University graduate student (one of authors) at teacher training faculty gave this class.

The objective of this class is to let students at secondary school get interested in energy saving technology adopted in electric vehicle through experiment and understand that the

![Fig.14 Did you enjoy participating in this class?](image-url)
advance of technology contributes to effective use of energy, resources, and environmental protection.

The class began with reviewing current situation of environmental problem and the causes of global warming from the view point of daily life. Students focused that emission gas from automobiles with combustion is increasing a lot these days, and compared this car with electric vehicle. Next, they learned the energy-saving technology such as speed control and regenerative braking system adopted in electric motor through experiment using the basic experiment kit. Moreover, they got on the handmade electric vehicle shown in Fig.7, and felt acceleration and regenerative brake. After getting off the electric vehicle, they checked accumulated energy from regenerative braking system by measure of energy composed of microcontroller. They were asked to calculate how long handy game machine worked by this energy. Finally, they watched the video concerning energy by regenerative brake, which was taken inside commercial hybrid car by us.

The class was evaluated by questionnaires. Figure 14 shows the result to the question “Did you enjoy participating in this class?”, where 89% of students answered “Yes” and 11% of the rest “Somewhat”. It is seen from this figure that almost all students enjoyed this class. Student’s understandings of energy-saving technology are shown in Fig.15. This figure says that there is no student who answered “Not at all”. Thus, we consider that learning through experiment
will be effective. Figure 16 shows student’s understanding concerning relationship between electric vehicle and global warming problem from the viewpoint of emission of CO\textsubscript{2}. This figure says that 95\% of students understand and that there is no student who answered “Not at all”. These results of questionnaires demonstrates the effectiveness of this class.

6. Conclusions

We have developed electric vehicle, measure of electrical energy and basic experiment kit as teaching material by which students are able to ride on and experience energy saving technology of PWM speed control and regenerative braking system. The objective of this class is to let students at secondary students get interested in energy saving technology adopted in electric vehicle through experiment and understand that the advance of technology contributes to effective use of energy, resources, and environmental protection. The class concerning energy saving technology at secondary school was implemented. Results of questionnaires demonstrates the effectiveness of this class.

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Abstract
This study has aimed to explore features of collaborative learning activities taking place in virtual spaces. The experiment was carried out with a group of teachers and students in Paraguay over a period of twelve weeks, on an open-source e-learning platform called MOODLE. A technological proficiency test was applied to inquire into participants’ background with computers. Students and teachers interacted using a group of selected tools for collaboration available on the learning platform. Results indicate that structural features on the platform are intuitive enough to facilitate operational fluency for different kinds of users. At the same time, support, empathy and stimulation from peers and tutors seem to be critical aspects for successful outcomes on the online collaboration. The virtual space has been found effective to work on valuable educational targets such as critical thinking and self-expression. Experiences on the learning platform seem consistent with its theoretical foundations, although more research is needed to identify particular conditions for successful learning outcomes in virtual spaces.

1. Introduction
The adoption of e-learning platforms has extended over the last years, particularly with the proliferation of open source systems that has rendered these facilities more accessible not only to educational institutions but also to a variety of national and international, private and public organizations that are taking advantage of virtual spaces to deliver alternative forms of distance or blended education and training.
Although the technology underlying such open systems has reached significant levels of development, and the number of users has grown considerably, instructional qualities have been as yet little documented through systematic experimental works with teachers and students. Characterizations found in scientific reports usually provide detailed accounts of structural, organizational and functional attributes of units under study; however few reports have been found where final-user’ experiences applying these systems in actual educational scenarios are given predominance. (see for example, the comparative evaluations documented in [1, 2, 3, 4, 5, 6])

As the number and variety of learning platforms increase over time, concern has began to grow within the educational community as to the nature of these new environments and their relationships to more traditional teaching and learning settings. In fact, the revision of learning theories to account for experiences taking place in virtual spaces has already been suggested [7] along with the generation of an alternative theory that takes into consideration the particular nature of elements present in online learning that render traditional theories insufficient to explain and predict subjects’ behaviors.

The relevance of a serious enquiry into theoretical underpinnings of learning in virtual spaces is evident upon the recognition of how spatial configurations affect human activities. Since the term “built pedagogy” was introduced to refer to “architectural embodiments of educational philosophies” [8], educators have become more aware of how the way in which a space is designed shapes the pedagogical experience that takes place therein. As a fundamental premise, this assertion should not be limited to physical spaces but also regarded as appropriate for virtual arenas and lead the exploration of the diversity of learning platforms currently on the market.

Research on e-learning platforms provides several indications concerning momentum and pre-eminence of different open-source choices. According to this reference, Moodle would be positioning as the most popular and versatile online learning environment worldwide, as several institutions continuously migrate from well-known commercial applications to this system [9]. Moodle
is defined as an open source Course Management System (CMS), it was first released in 2002 as an educationally sound alternative to Blackboard at Curtin University of Technology in Australia [10]. In its basic form, it offers a variety of teaching and learning tools and it has called the attention of users for several merits as compared to other packages, among them easy extensibility, several interface languages, easy record-keeping, logs and tracking [11].

At the same time, a particular advantage of Moodle seems to be a consolidated strategy of collaborative software development that is based on end-user experiences and keeps the system frequently receiving contributions of innovative modules. On this account, several features that were not present in earlier versions are already included as part of the core structure in last releases. This might be seen as an asset; however, from a pedagogical point of view the question remains as to the relevance and need of such a conglomeration of tools made available for this system.

On the other hand Moodle is also presented as a product of rigorous theoretical analysis both in educational and communicational domains. In fact, its developers often refer to socio-constructivism, collaborative work and communicative action as foundational positions to deploy a computer-based learning environment [12, 13, 14]. Although there is still intensive debate concerning actual realization of theoretical paradigms that Moodle claims to promote, there is little doubt that facilities provided by this system, along with a “steep” learning curve have set up favorable conditions for a rapid expansion across the e-learning market.

A review of the literature concerning Moodle revealed that a number of evaluations were already carried out to explore instructional features [15, 16, 17, 18, 19] compare technical qualities with similar packages [20] or extend basic capabilities for innovative instructional approaches [21, 22, 23, 24, 25, 26]. On the basis of previous discourse, Moodle has been selected in this study as a suitable experimental setting to contribute to academic discussions concerning qualitative features on an e-learning platform that makes them better choices to promote quality educational experiences in virtual spaces.
2. Methodology

As a first step in the course of this study, an educational project was developed involving representatives from institutions participating in this initiative: the University of Kagoshima in Japan and the Higher Institute for Teacher Education “Dr. Raul Peña” in Paraguay.

General foundations and activity guidelines for the project were summarized in a document titled “Collaborative Project: Learning in Virtual Spaces”. Participation was open to teachers, student-teachers and educators in general that could be interested in the educational use of computers, particularly in teaching and learning processes that take place in virtual environments.

As general objectives were established: a) To experiment with functionalities of different tools available on Virtual Learning Environments; b) To explore didactic features of learning experiences taking place on a Virtual Learning Environment; and c) To reveal consistent connections between practical operation of a virtual learning environment and the theories supporting their development. (e.g. socio-constructivism, communicative action, etc.) At the same time, some specific topics for the online discussion were selected: a) Computers in Education. Foundations and Principles; b) How are computers used at schools? Examples; and c) Conditions for a sound implementation of computers in schools. A calendar of activities was proposed as shown in Figure 1.

<table>
<thead>
<tr>
<th>ACTIVITIES</th>
<th>August 2007</th>
<th>September 2007</th>
<th>October 2007</th>
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<tr>
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<td>Week Nr.</td>
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<tr>
<td>1. Preliminary Organization</td>
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<td>2. Registration and Diagnostic Assessment</td>
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<td>3. Introduction of Participants</td>
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<td>4. First Task Assignment</td>
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<td>5. Research Period</td>
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<td>6. Interaction Period</td>
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<td>7. Second Task Assignment</td>
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<td>8. Research Period</td>
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<tr>
<td>9. Interaction Period</td>
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<td>10. Final Discussions</td>
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<td>11. Project Evaluation</td>
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**Figure 1** Schedule of the Project “Learning in Virtual Spaces
A survey was then conducted on participants’ registration process in order to collect data about technical competences and attitudes towards collaborative work. The instrument contained 13 questions concerning participants’ experience in the use technical equipment and software and 12 questions concerning personal attitudes towards collaborative work. Contents of questions included in the survey are shown in Table 1. Information collected in the diagnostic assessment was helpful to generate a profile of the experimental group and design more appropriate teaching and learning activities.

Forums, glossaries, chats, questionnaires and wikis, available as core tools on Moodle, were selected as teaching and learning aids to be used in this project. As a first activity, an introduction forum was set up where participants had an opportunity to provide brief references about themselves and their expectations regarding the online exchange. After this stage, a reading material was posted in a separate discussion forum with the title “How can computers contribute to Education?” Students were required to read the material and post their comments about it. A dynamic exchange followed based on postings that lasted for about 2 weeks. Discussions were summarized and a conclusion was posted on the project’s Wiki. At the same time, terms were added to the Glossary, according to students’ suggestions.

### Table 1 Questions included in the Diagnostic Evaluation

<table>
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<tr>
<th>Part A. Experiences with the use of computers</th>
<th>Part B. Perceptions about collaborative work</th>
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<tr>
<td>Q1. You use computers at least 2 hours per day</td>
<td>Q1. In the past, you have worked in several collaborative groups for learning purposes.</td>
</tr>
<tr>
<td>Q2. You are able to perform basic tasks of computer operation (e.g., create, copy, move, paste, delete files and/or folders)</td>
<td>Q2. Collaborative work is a good teaching practice for students to reach more comprehensive learning outcomes.</td>
</tr>
<tr>
<td>Q3. You browse the Internet at least 2 hours per day</td>
<td>Q3. Collaborative work can be a very effective method to support learning in online education.</td>
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<tr>
<td>Q4. You exchange email every day</td>
<td>Q4. You have previous experience working on multidisciplinary collaborative projects.</td>
</tr>
<tr>
<td>Q5. You use a word-processor every day</td>
<td>Q5. Collaboration consists in contributing with our best talents and skills to reach one or more objectives collectively agreed upon.</td>
</tr>
<tr>
<td>Q6. You work with spreadsheets every day</td>
<td>Q6. Reaching goals in a collaborative project requires personal commitment from everyone involved.</td>
</tr>
<tr>
<td>Q7. You use database administration programs every day</td>
<td>Q7. In a collaborative work, the experience and contribution from all participants is vital to reach learning objectives.</td>
</tr>
<tr>
<td>Q8. You use graphic design programs every day</td>
<td>Q8. Balancing individual interests and group objectives is crucial for successful collaborative works.</td>
</tr>
<tr>
<td>Q9. You are able to create multimedia files (e.g., audio, video and/or animations)</td>
<td>Q9. Collaborative work requires more time, effort and resources to reach educational objectives, as compared with individual work.</td>
</tr>
<tr>
<td>Q10. You have experience developing web-pages for the Internet</td>
<td>Q10. Collaborative work at school is a fundamental strategy to prepare students for their future social and productive life.</td>
</tr>
<tr>
<td>Q11. You have experience with tele-conferences (text-, audio- and/or video-chat)</td>
<td>Q11. Success of collaborative works over the Internet can be affected by problems inherent to human interactions in virtual environments (e.g., asynchronous communication, indirect and mediated contact, non-verbal communication, etc.)</td>
</tr>
<tr>
<td>Q12. You use tools for collaborative interaction online (e.g., bulletin boards, list-servers, blogs, wikis, podcasts, etc.)</td>
<td>Q12. An important disadvantage of collaborative work is that students can not progress at their own pace, as they must comply with the rules agreed upon in the workgroup.</td>
</tr>
<tr>
<td>Q13. You are able to operate computers following safety recommendations to protect your health and ensure proper working of your machine.</td>
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The cycle was repeated on the following stage with a second reading material titled “What can be done with computers at school?” Discussions in the second forum were summarized with a corresponding document on the project’s wiki. Two videos were then uploaded, one of them showing an actual learning experience using computers in kindergarten and another using them in High School. Students were asked to observe these experiences and indicate aspects that most impressed them concerning: a) student’s work with computers, b) the teacher’s role in the classroom; c) the general learning environment (including the physical conditions, students’ interactions, student-teacher interactions, etc); and d) other aspects they might have found relevant. A chat session was carried out as an opportunity to exchange final comments and impressions on the experience using the e-learning space. Interactions were carried out on an instance of Moodle, as shown in Figure 2.

![Figure 2 Instance of the Learning Platform](image)

The experience underwent a twofold evaluation: an adaptation of the COLLES (Collaborative Online Learning Experience Survey) survey [27] was employed to get a qualitative perception on the online learning experience and a separate instrument called “Pedagogical and Operative Assessment of Moodle” was developed to assess usability features on Moodle. The latter
instrument comprises 29 questions inquiring into 6 different aspects of the learning platform: Structure, Operation, Learning Features, Documentation, User Support and User Satisfaction.

3. Results and Discussion

The diagnostic assessment carried out among participants, resulted in relevant data to organize learning activities in the project. 23 participants in Paraguay registered for this experience, 57% of which were male and 43% female. A 57% of this group was composed of student-teachers, another 30% were teacher trainers and the remaining 13% were classified as “educators” as they were somehow involved in the educational field but not involved in lectures with students. Attachments to academic departments were diverse: Social Sciences, Mathematics, Electronics, Educational Technology, Spanish/English Language, Physics, Evaluation and Long-life learning. Participants’ technological proficiency and attitudes towards collaborative work that were revealed by the survey are shown in Figures 3(a) and 3(b), respectively.

![Figure 3](image-url)

(a) Technical Proficiency (O. P. = 43%)  (b) Attitudes towards Collaborative Work (O. P. = 83%)

**Figure 3 Participant’ Diagnostics**

To produce these figures, the Likert-scale-type answers in the survey were quantified using a scale of 1 to 5, with “1” corresponding to “Totally disagree”
“5” corresponding to “Totally agree”. Figure 3(a) reveals a rather low overall performance of 43% in questions regarding previous experience using different kinds of computer tools and accessories. The lowest scores were obtained on following items: a) Experience developing web pages (45%); b) Experience with graphic design (47%); c) Experience with tools for collaborative interaction on line (e.g. newsgroups, blogs, wikis, podcasts, etc.) (48%); d) Experience with database programs (51%) and e) Experience with online teleconferences (text-, audio-and/or video-chat) (55%). For the purposes of this project, it was particularly important the scarce previous experience using tools for collaborative interaction online indicated by participants.

On the other hand, Figure 3(b) reveals rather positive attitudes towards collaborative work with an overall score of 83% in issues explored by the survey. Participants’ responses suggest that the group is aware of the complexity of a collaborative work in virtual spaces. This was recognized as a positive condition for the success of learning activities planned in the project.

Results from the COLLES survey are shown in Figure 4. The COLLES items are organized into six scales, each of which helped addressing a key question about the quality of the on-line learning experience: Relevance, Reflection, Interactivity, Tutor Support, Peer Support and Interpretation. Some aspects were observed as the weakest during the online experience:

a) Little encouragement, empathy and appreciation from peers
b) Little stimulation and encouragement for participation from the tutor
c) Interpretation problems in the discourse of the tutor and messages sent by participants

The best aspects of the experience were indicated as:

a) Critical thinking was stimulated through peers ideas and the reading material
b) The topics discussed were relevant for the professional practice of participants
c) It was an opportunity to explain participants’ own ideas concerning the topics discussed
Questions related to each dimension included in the COLLES survey were grouped and following results were obtained: Relevance: 70%; Reflection: 82%; Interactivity: 73%; Tutor Support: 55%; Peer Support: 35%; Interpretation: 72%. These numbers indicate that the online experience was a good opportunity to stimulate students’ reflection on the topics covered which were regarded as relevant. Communication among teachers and students seem to have been fluid and dynamic, while support was little available either from peers or tutors.

4. Conclusions

“Learning in Virtual Spaces” has been an opportunity for teachers and students to experiment with different kinds of tools, interaction and communication patterns that are typically found in virtual learning environments. At the same time, directions have been provided for future inquiries into technical and pedagogical requirements conditioning successful learning experiences in online spaces and their relationships to users’ profiles.

The diagnostic evaluation carried out among participants revealed a group of individuals with basic computer skills that despite their manifested lack of
experience with tools for collaborative interaction rapidly managed to find their way around the e-learning platform and progress with the assigned tasks without much interference. This finding would suggest that structural features of the platform are intuitive enough for users to develop “operational fluency” in a short period of time. Furthermore, the diversity of participants in gender, age and role within the educational process suggests that this quality of the learning platform employed in the project would not be tied to arbitrary user-related features.

Particularly critical in the experience seems to have been students’ need for support, approval and stimulation from peers and tutors. This poses a serious challenge for online learning, as the lack of face-to-face interaction modifies the way students can be motivated to achieve educational goals. Tools on the learning platform selected for the experience shaped communication patterns observed during the exchanges and participants’ indication of insufficient peer and tutor support could be interpreted as a need to make motivational clues more explicit than the way they are usually required in conventional didactical communications. In the same vein, problems found to interpret tutors and peers’ discourse along the exchanges suggests the need to emphasize descriptive details in communications taking place on virtual spaces.

On the other hand, the virtual space has been found effective to work on valuable educational targets such as critical thinking and self-expression. At the same time, the assessment of the experience as “relevant” for participants’ professional practice is a good incentive to replicate in the future the same kind of initiatives introducing different kinds of tools available on the platform.

As a final note, it is appropriate to note that levels of interactivity, relevance, reflection and interpretation registered in the COLLES survey suggest consistent connections of theoretical foundations proposed for the learning space and actual realizations in terms of teaching and learning processes. Further inquiries would nevertheless be required in order to establish particular conditions in which these realizations are most likely to be achieved.
References


1. Abstract

It is important to promote international cooperation and mutual understanding by exchanging the data of teaching materials internationally. The method of making of teaching materials is also established and has in common on a world-wide level. It is necessary to bring up pupils who are good at making of things. The development of teaching materials for making of castings in junior high school has conducted. In this paper, how making of castings is carried out and how pupils think about this making of castings is discussed. To carry out making of things in the school work, the equipments are prepared. A cylindrical small furnace, (i.e. Japanese Hichirin, which is inside diameter of 130mm, outside diameter of 180mm, inside height of 180mm and outside height of 220mm), is set. Burning cokes are inserted into the furnace and air is fed from lower side of furnace by using air feeder to burn the cokes. Used vacant aluminium cans in the iron pot are melted and cast into the sand mould. Key holder and name plate castings are made with aluminium cans. According to the questionnaires for pupils, it is cleared that they are interested in this teaching material highly.

2. Introduction

Japanese youth has been interested in making of things poorly recently\(^1\(^2\). Making of things relates to development of technology largely. It has been reported that the number of young successor to the Japanese traditional art and craft is small\(^1\(^2\). There is anxiety about future for development of science and technology in Japan\(^1\(^2\). So Japanese Ministry of Education promotes science and technology education positively. Teaching exercise for making of things in
Japanese junior high school has carried out actively. As one of teaching exercises, making of aluminium castings has reported. However there are some problems for this teaching exercise which is conducted in junior high school. For example, ① it is difficult to keep the temperature of furnace high in order to melt aluminium. ② A member, which composes of teaching, is a teacher and more than twenty pupils in a Japanese technology education lesson of junior high school. So attention in teaching exercise from a teacher to pupils is not careful enough. ③ This teaching exercise tends not to finish within a lesson time. ④ Water in sand mould has the role of binder between sands. However water in sand mould vaporizes and sand mould collapses with increase in time. ⑤ As temperature of furnace do not rise enough under the condition by burning cokes, aluminium cans do not melt enough. ⑥ Gas defects are apt to produce on the surface of castings as sands contain water merely.

The development of improved method is necessary for pupils to make castings successfully. In this paper, how making of aluminium castings conducts successfully is discussed.

3. Experimental Procedures

This teaching was carried out at the Hirakawa junior high school Yamaguchi JAPAN. And also it was conducted at Hikari and Yamaguchi lower secondary school affiliated to Yamaguchi University JAPAN. It had been conducted during 2003 to 2004. About eighty pupils attended this teaching. The pictures of condition for this teaching were taken and the examination of questionnaires for pupils who attended this teaching was conducted.

4. Results

4.1 Processes of making of castings

Fig.1 shows the flow chart which indicates making processes of aluminium castings and questionnaires. To keep strength of sand mould longer, the materials are added to the mould as shown in Fig.1③. The processes for ① design for pattern, ② patternmaking, ③ moulding, ④ melting and pouring, ⑤ cleaning of castings and ⑥ questionnaires for pupils are carried out.
Fig. 2 is the photograph which a teacher explains about a small furnace named Japanese Hichirin. Fig. 3 shows some patterns for key holder in steel plate frames. A pair of steel plates, whose thickness of 1mm, length of 430mm and width of 40mm is prepared. It is bent at the length of 200mm and 400mm from the edge in the shape of U character respectively. A pair of them is combined in the shape of square and their outside is fixed by using two steel wires of diameter of 2mm in Fig. 2. Pattern for key holder is made with paper clay. It is also made of wooden plate and foamed styrol. Foamed styrol is adhered to wooden plate by paste. Runner, whose size is thickness of 7mm, length of 20mm and width of 15mm, is made with paper clay and it is put in the steel plate frame together with pattern. Runner is a way which melted metal passes. Fig. 4 indicates pattern (arrow A) and runner (arrow B). Pattern and runner in steel plate frame is shown in Fig. 5. Moulding sands are added over the pattern and tamped down by a rod-like steel bar as shown in Fig. 6 and Fig. 7 respectively. Fig. 8 shows that a pupil removes pattern and runner from sand mould by using a pick. The choice of cast iron pot (arrow D) is made comparing with some other pots in Fig. 9. Namely as cast iron pot (arrow D), which is outside diameter of 150mm, depth of 55mm and thickness of 3mm, has heat-resistance, it is used repeatedly as a pot for this melting. Heated red cokes are inserted into the pot and fresh air is fed continuously from the lower part of it to burn cokes. Fig. 10 shows the apparatus for melting. In Fig. 10 arrow B, arrow C, arrow D, arrow E and arrow F are air feeder, some burned cokes, an iron pot, steel plate wall for wind break and Japanese small furnace named Hichirin. Vacant used aluminium cans are melted in the pot on the Hichirin. Vacant used aluminium cans in the pot as shown in Fig. 11. As temperature of pot increases, aluminium cans begin to melt in Fig. 12. Arrow G, arrow H, arrow I and arrow J are stage, iron pot, aluminum can, burned cokes respectively. As shown in Fig. 13, a can melts down about thirty seconds later after melting condition in Fig. 12. Melted aluminium is cast into the mould by pupils as shown in Fig. 14. Fig. 15 indicates a photograph of aluminium castings for key holder which is extracted from mould after solidification of aluminium. Fig. 16 shows an aluminium casting which has four key holder castings and arrow A, arrow B and arrow M show key holder, runner and feeder
respectively. Fig.17 shows the condition that a key holder is cut from the whole of castings by using a saw. The condition, which a pupil touch up a key holder with a file, is shown in Fig.18. Key holders after cleaning are shown in Fig.19. Fig.20 indicates name plate castings removed from a sand mould and arrowK and arrowL show two name plate castings and sand mould respectively. Fig.21 shows two name plate castings with feeder and arrowK and arrowM is name plate and feeder respectively. Fig.22 indicates two name plate products removed from feeder and cleaned.

The development of improved method is necessary for pupils to make castings successfully. In foreign countries, technology education for making of castings has carried out. Exchanging of the data for teaching exercise on a world-wide level promotes international cooperation and understanding for technology education in world.

4.2 Results of questionnaires for teaching by pupils

The results of questionnaires for pupils show Fig.23 to Fig.30. It is clear that almost pupils have not seen the melted metal according to Fig.23. Fig.24 and Fig.25 indicate that pupils are interested in teaching highly and face this lesson positively respectively. It is difficult for pupils to make pattern(②) and moulding(③) and clean up the castings(⑤) according to Fig.26. Fig.27 and Fig.28 show that pupils are tolerably satisfied with design of pattern and product. It is clear that all pupils want to conduct melting and pouring of aluminium castings once more according to Fig..29. Fig.30 indicates that pupils rate this teaching and product high generally.

5. Conclusions

Making of castings by using vacant used aluminium cans has been conducted in junior high school. In this paper, how exercise is carried out successfully is discussed. Results can be summarizd as follows.

1) Moulding sands, which compose of sand for bronze castings, bentonite, corn powder, starch binder and water, keep strength of mould. This mould is suited for this casting in school work. Iron pot for melting, which has the size of outside diameter of 150mm, depth of 55mm and thickness of 3mm is useful for melting of aluminium cans by using Japanese type
furnace, Hichirin.

2) Steel plate wall for wind break is useful to keep temperature of furnace high. According to questionnaires for this study content, pupils are interested in this content of exercise highly. It is evident that this teaching exercise for making of things is useful.

5) The improved method in school lessons is necessary for pupils to make things successfully. In foreign countries, technology education for making of things has carried out. Exchanging of the data for making of castings on a world-wide level is necessary to promote international cooperation and understanding in technology education.

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Yasumasa Yoshikawa Kameya Com. Shunan Yamaguchi JAPAN and
Hiroshi Fujitsu Migita Junior High School Hofu Yamaguchi JAPAN.

References


Fig.1 Flow chart of this teaching

| 1. Planning of design for pattern | ↓ |
| 2. Patternmaking | ↓ |
| 3. Moulding (moulding sands are composed of sand for bronze castings, bentonite, corn powder, starch binder and water) | ↓ |
| 4. Melting and pouring | ↓ |
| 5. Cleaning of castings | ↓ |
| 6. Questionnaires for teaching by pupils |

Fig.2 | Fig.3 | Fig.4
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Fig.5 | Fig.6 | Fig.7
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Fig.2-22 Processes for making products.
Fig.23-30  Results of questionnaires for teaching by pupils after lessons.