THE DEVELOPMENT OF BENCHMARKS AND THE SELECTION OF APPROPRIATE METHODS TO ASSESS TECHNOLOGICAL LITERACY PORTION OF THE NATURAL SCIENCE AND LIVING TECHNOLOGY CURRICULUM AS REQUIRED BY THE 2000 NATIONAL CURRICULUM GUIDELINES OF THE REPUBLIC OF CHINA (TAIWAN)

DISSERTATION

Presented in Partial Fulfillment of the Requirements for

the Degree Doctor of Philosophy in the Graduate

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By

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ABSTRACT

The purpose of the study is to identify the essential benchmarks of technological literacy to be required of 9th graders in Taiwan, and to determine assessment methods for these benchmarks. Its results, the clarification of the benchmarks of technological literacy as well as the appropriate assessment tasks, provide a foundation for what technological literacy means to technology teachers and students in Taiwan, and offer assistance to their instruction and assessment, professional development, and program evaluation.

The Delphi technique was employed in the study that consists of one initial survey and three reiterative questionnaires. Twenty-four panelists, all technology education professionals with extensive teaching and research experience in Taiwan, participated in the study.

The initial survey, Delphi probe, was designed to collect a provisional list of benchmarks and assessment tasks for measuring technological literacy. A list of 105 benchmarks and five assessment tasks was compiled from the responses to the initial survey.

In the first round of the study, participants responded to rate the importance of each benchmark using a four-point Likert scale. The importance and level of agreement of each of the 105 benchmarks was then examined by calculating the arithmetic mean, mode, standard deviation, range, and data distribution. The criteria for lack of consensus include: a standard deviation of .780 or higher and an agreement level of 60% or lower. These were maintained into the next questionnaire. Thirty-five benchmarks that were commonly

rated as very important were accepted and nine benchmarks that were commonly rated non-important were eliminated. The remaining sixty-one benchmarks that did not reach consensus were maintained into the next questionnaire for further inquiry.

In the second-round questionnaire, participants were shown the mean score of each benchmark with his or her rating from the previous round. With this information, they could reconsider their rating when filling out the second questionnaire. Based on the responses toward the 61 benchmarks, seventeen benchmarks that were commonly rated as very important were accepted, seven benchmarks that were commonly rated non-important were eliminated, the remaining thirty-seven benchmarks that did not reach consensus were maintained into the next questionnaire for further inquiry.

In the third round, participants received information about both the mean scores and her/his rating of each benchmark from the previous round. The result of this round of inquiry shows that only eight out the remaining thirty-seven benchmarks were determined important with a satisfactory level of agreement and accepted the rest were eliminated.

Through the three rounds of Delphi studies, 60 out of 105 benchmarks were identified as important benchmarks. Their level of importance was analyzed and thematic connections between the benchmarks were explored. Furthermore, they were presented in five categories: Understanding of Technology, Inquiry and Analytical Skills, Communication Skills, Design and Build Skills, and Application and Problem Solving Skills.

Dedication

To my parents 王士俊楊淑賢雙親,

My sisters/brothers, 景禹, 維娜, 維莉, 維新, 大用, 亮 and

My dear wife 志明 and children 實之, 行之

For their high expectation, love, patience, and understanding.

謹以本論文之完成 誌謝 雙親之養育鐘愛及期盼

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PUBLICATIONS

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Wang, K.F. (1986). The Programming of Programmable logic Controllers, Hua-Sin Pub. Co., Taipei, Taiwan.

Wang, K.F. (1987). The Textbook of Industrial Arts for Senior High (part 3: Energy Industry) , Jen-Chung Pub.Co.,Taipei,Taiwan,1987.

Wang, K.F. (1987). "The Contents and Significance of Energy Education", High School Industrial Arts Monthly, Taiwan, 20(7), pp.2-7

Wang, K.F. (1989). The Manipulation of Programmable logic Controllers, Hua-Sin Pub. Co., Taipei, Taiwan.

Wang, K.F. (1990). "How to Make a Teaching Aids to teach the Concept of Torque", High School Industrial Arts Monthly, Taiwan, 23(12), pp.20-24

Wang, K.F. (1991). The Handbook of Smart motor Controllers, Allen-Brandly Co., Taipei, Taiwan, 1991.

Wang, K.F. (1991). "The Developing of Experimental Auto-Retrieving System with a Robot", High School Industrial Arts Monthly, Taiwan, 24(6), 10-16

Wang, K.F. (1994). “Instruction Manual for Integrated Machical and Electrical Occupations” (Electrical Division), ROC Bureau of Vocational Trainging.

Wang, K.F. (1999). “The Design and Development of Learning Activities for Integrated Technology Education”, International Conference on Technological Integrated Thinking. National TaiTung Normal Uiversity, Taiwan, March 2-5, 1999.

Wang, K.F. (1999). “A Teaching and Training Model for High Technology Human Resource Development”, 1999 High Technology Human Resource Development Seminar, NTNU, Taiwan, May 14-15, 1999.

Wang, K.F. (2000).”The Strategies and Implementation of Training Evaluation,” Employment and Trainging Bi-Monthly, Taiwan, 18(1), 60-66, 2000/1/1.

Wang, K.F. (2001).” SWOT Analysis of development of technology Education Across the Taiwan Strait”, OCAPA Conference, Toledo,Ohio, 2001/5/31.

Wang, K.F. (2002).” Modern vs. Traditional Methods for Inquiry in the fields of Education, Humanistic Studies, and Sociology”, OCAPA Conference, Columbus, Ohio, 2002/6/15.

Wang, K.F. (2002).”Basic Concepts and Significance of Technology”, Living Technology Monthly, Taiwan, 35(9), 2-6, 2002/9/1.

FIELD OF STUDY

Major Field: Education

Technology laboratory Instruction – design and implement learning activities.
Basic working skills -- mechanic, welding, plumbing, woodworking, etc.
Pneumatic and Hydraulic systems and devices,
PLC (programmable logical controllers)-- I/O wiring, programming,
Electrical wiring -- industrial and residential, and circuit diagnosis,
Robotics -- Installation, manipulation and control,
Energy and power -- experimenting and problem-solving.

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CHAPTER 1

INTRODUCTION

Background of the study

In the past few decades, the people of the Republic of China (ROC, the official name of Taiwan) have experienced tremendous economic and social changes (Accenture, 2002) in a highly technological world. Meanwhile, under the thrust of economic prosperity, the education system in Taiwan has flourished, and it has been urged to undertake reform. To meet this need, the ROC Ministry of Education promulgated new National Curriculum Guidelines on September 30, 2000.

One reason behind this focus on education is that natural resources are scarce in Taiwan. The only plentiful resource in Taiwan is its population that was over 22,554,000 in June 2003 (Department of Statistics, 2003). Because Taiwan is one of the most densely populated areas on earth, human resources are Taiwan's treasure, but also a heavy burden. Taiwan relies much on education to support its survival, to sustain its economic development, and to keep its competitive role in international society.

Traditionally, the principal goal of K-12 education in Taiwan is to reach a balance among five major categories of education: moral/ethic education, intellectual/academic education, physical education, social/interpersonal education, and esthetic/fine arts education. Education in Taiwan is based on a mixture of Western educational philosophies and theories of Confucius and other Chinese philosophers. For example, theories of technology education also existed in ancient China. According to Kan (2000), the principal goals of education in the Zhou Dynasty (1027-221 B. C.) were the "six most important arts (六藝)", which include rites, music, archery, riding, reading and writing, and mathematics, (禮樂射御書數). Currently, even though the school system, curricula, learning theories, and other educational practices are copies of Western style, the in-depth ethical and value judgments are still Chinese in character.

Technology education has made a great contribution to the people of Taiwan, enabling them to understand and use technology during times of rapid technological change. The learning outcomes of technology education are referred to as "technological literacy," which can be defined as the knowledge, skills and attitudes required to design, modify, use, and apply technology. Technological literacy is also defined as the ability to solve technological problems, to make informed choices and decisions about technology, and to advocate for responsible technological behavior (HCPS, 2001).

In recent years, technology education in Taiwan has gradually gained an important role among the courses of general education. Not only has it been assigned as a required course but it has also been extended from secondary to primary schools.

The course title of technology education has been changing from industrial arts, industrial technology, and Living Technology. After the new national curriculum was promulgated in 2001, technology education was assigned a portion of the course "Natural Science and Living Technology" and was called "Living Technology."

To meet the demand for technology teachers from schools, undergraduate and graduate programs of technology education in universities in Taiwan were established during the last half-century. Precisely, the undergraduate programs, master degree programs, and doctoral degree programs of technology education were initiated in 1953, 1976, and 1998 respectively (NTNUITE, 2002).

However, there is a common problem in the assessment of technological literacy in Western and Eastern countries. Boser, Palmer, and Daugherty (1998) asserted that there is an insufficiency of accepted or standardized measures of technological literacy, so that it is difficult to assess and compare various forms of instruction in technology education. Additionally, these pressures are forcing technology education professionals to recognize the need for assessment of technological literacy.

Technology teachers in Taiwan require clearly defined assessment tasks and scoring methods (Chiang, 2000) to answer questions like: “What are realistic expectations for students?” or “How will I know if my students, and I, are succeeding?” The need is even more acutely felt because a totally new technology curriculum, as demanded by the ROC 2000 National Curriculum Guidelines, was implemented in 2001.

There is little research on the assessment of technological literacy in Taiwan. A searching of the “Database of Research Papers in Education” (NIOERAR, 2003) of Taiwan on July 12, 2003 revealed: although 1,472 and 288 articles were found by using the keywords “Assessment” and “Living Technology OR Technological Literacy” respectively, there were only 19 articles contain both of the above two keywords. Furthermore, none of the 19 articles discussed the assessment of technological literacy.

A search of the "Thesis and Dissertation Database" (DATAS, 2003) of Taiwan on the same day with the criteria "Assessment AND Technological Literacy" yielded 39 theses. Among them, only two master's theses can be regarded as pertinent to the function of evaluation/assessment of technological literacy. Furthermore, the instruments with which the two studies used to measure the technological literacy were developed in 1994, which posit different perspectives from that of today. The need of instruction and assessment revealed above creates the necessity of this study.

Statement of the problem

A well-developed curriculum standard can be used in selecting and developing curricular materials and pedagogy. However there is an insufficiency in the ROC 2000 National Curriculum Guidelines in terms of the specific performance criteria for technological literacy for both instruction and assessment. Specifically, the existing learning objectives recommended in the National Curriculum Guidelines for technological literacy do not satisfactorily meet the needs of teachers and students in the teaching and learning of technology, professional development, and program evaluation.

In addition, the prevailing assessment methods in the course of technology education rely heavily on paper-and-pencil tests and quantitative grading (Chiang, 2000). Therefore, the problem statement is as follows: educational research about performance assessments in the field of technology education is inadequate. In addition, the brief description of learning objectives published in the ROC 2000 National Curriculum Guidelines is insufficient for guiding the instruction and assessment of "Living

Technology." Consequently, technology teachers in Taiwan are facing a shortage of objective assessment criteria and adequate assessment tools in their instructional practices (Shi, 2002). In fact, many of them do not know how to do performance assessments (Ni, 1995; Peang, 1998; Chiang, 2000). Specific benchmarks of technological literacy need to be determined, adequate alternative assessment tasks and effective assessment rubrics for them need to be created, and an implementation plan needs to be developed to modernize the assessment of "Living Technology" which currently relies solely on traditional paper-and-pencil tests.

Purposes of the study

With the intention to implement the ROC 2000 National Curriculum Guidelines effectively, the important benchmarks and assessment methods for technological literacy for ninth graders of junior high schools in Taiwan were identified based on the perceptions and consensus of experts in Taiwan.

Specifically, the purposes of this study were to: (a) determine the important benchmarks that are required of the ninth graders in Taiwan, in three categories of technological literacy -- "Development of Technology," "Design and Make," and "Thinking Skills," and (b) determine appropriate assessment tasks for each categories of technological literacy.

The clarification of important benchmarks and appropriate assessment methods developed in this study can guide classroom instruction and assessment of "Living Technology." With the information, technology teachers in Taiwan can answer questions such as “Do junior high school graduates (ninth graders) meet the requirements of the ROC 2000 National Curriculum in the domain of “Living Technology?” or “Do students have the ability to apply the technology they have learned to the challenges of life beyond school?”

The findings of this study should promote better recognition of the benchmarks and better understanding of assessment tasks among technology professional in Taiwan. Therefore, technology teachers’ abilities to teach, assess, mentor their students, and to implement the ROC 2000 National Curriculum will be enhanced.

Research questions

Based on the above purposes, the following research questions were used to guide this study:

1. What are the appropriate benchmarks to assess technological literacy in the area of “Development of Technology” a portion of the Natural Science and Living Technology curriculum as required by the ROC 2000 National Curriculum Guidelines in Taiwan?
2. What are the appropriate benchmarks to assess technological literacy in the area of “Design and Make” a portion of the Natural Science and Living Technology curriculum as required by the ROC 2000 National Curriculum Guidelines in Taiwan?
3. What are the appropriate benchmarks to assess technological literacy in the area of “Thinking Skills” a portion of the Natural Science and Living Technology curriculum as required by the ROC 2000 National Curriculum

Guidelines in Taiwan?

4. What are the appropriate assessment tasks to assess the "Technological Literacy" a portion of the Natural Science and Living Technology curriculum as required by the ROC 2000 National Curriculum Guidelines in Taiwan?

Significance of the study

Technological literacy is the ability to address complex issues or to understand how to use evolving technologies. People need technological literacy to access resources effectively, to use technological products, equipment, or systems, and to manage, interact with, or change the outside world. The most efficient way for people to improve their technological literacy is to go to school to obtain technology education. Thus, the ultimate goal of technology education is to equip students with technological literacy. In other words, the content of technological literacy can be interpreted as the learning targets of technology education.

Because technological literacy involves complex performance more than simple understanding and application, the instruction and assessment of technological literacy are not simple tasks, compared to the teaching and assessing the factual knowledge.

Further, the achievement of technological literacy cannot be easily determined without clearly defined benchmarks and assessment methods for technological literacy. Similarly, lacking clearly defined benchmarks and assessment methods, teachers will be unable to focus instruction and reliably track student progress, and students will be unable to perform self-assessment and self-correction accurately.

In contrast, the identification of the benchmarks and assessment methods in this study establish a common set of expectations for what teachers should teach and what students should learn in the course of “Living Technology” in Taiwan. In addition, the research findings provide a basis for developing meaningful “Living Technology” curriculum that is coordinated with other disciplines and is articulated among different educational levels.

With the research findings, not only can all junior high school students learn more efficiently and effectively, but also all technology educators, teachers, and practitioners will function more realistically in achieving their educational mission and goals.

In other words, the results of this study provide direction for ROC Ministry of Education decision makers, junior and senior high schools in Taiwan to improve teachers’ recognition of the benchmarks of technological literacy, promote teachers' understanding of assessment tasks, and enhance teachers’ abilities to apply authentic assessment and to implement the ROC 2000 National Curriculum.

The familiarization of most technology teachers in Taiwan with authentic assessment procedures will have a great impact on the national standardized test -- “the Basic Competency Test” -- in Taiwan because it still relies on traditional paper-and-pencil tests. This impact may force the national competency test to apply some form of authentic assessment in the near future. Furthermore, the results of the study can also be exported across the Taiwan Straits to Mainland China because both share the same culture and have similar education systems.

In conclusion, the study is significant for a number of reasons. First, through the identification of benchmarks of technological literacy required for junior high school students, this study suggests explicit learning targets suitable for the instruction of the "Living Technology" domain of the course "Natural Science and Living Technology" in Taiwan. Second, the assessment methods determined in this study explicitly inform teachers in the appropriate ways to do classroom instruction and assessment. Technology teachers can use these assessment tools for summative assessment directly, or they can develop their own assessment tools for formative assessment by referencing the research findings. Thus, the benchmarks and performance assessment methods developed in this study provide technology teachers with more objective assessment tools for evaluating students' technological literacy both holistically and analytically. Furthermore, the identification of benchmarks and assessment tasks for evaluating technological literacy can be used as well by technology teachers and students in courses, and can be used as well by schools and district administration to evaluate technology programs. Finally, it creates the possibility that the ROC National Basic Competency Test will lead the way in using authentic assessment.

Assumptions

The following assumptions are inherent in the pursuit of this study:

1. All participants in the investigation and experts involved in the study responded cooperatively and bestowed their real perspectives with sincerity and honesty.
2. Even though the questionnaire was printed in English with Chinese translation, it is assumed that the Chinese translation of questions is consistent with the original

(English) version, and is able to express what the questions want to ask in a different cultural context. In other words, it is assumed that all participants and experts involved in the study in Taiwan could understand the meaning of the questions correctly, and that their perspectives and ideas were interpreted into English accurately.

3. All selected experts in this study had equal or better professional capability than their peers in the comprehension of technological literacy and in the experiences of assessing technological literacy of their students. Moreover, they are concerned with the assessment of technological literacy and came to agreement through the research processes.
4. All participants objectively made professional judgments on the assessment of technological literacy. They were not influenced by political considerations and treat the existing benchmarks in the national curriculum as irrefutable.
5. All participants agree to a criterion-referenced performance assessment and agree to use percentage-based grading.

Delimitation and limitations

The study was limited to a small number of experts from among technology teachers and technology teacher educators in Taiwan, and the study was restricted to the expertise of those individuals. Additionally, the scarcity and accessibility of relevant literature limited the resources for benchmarks of technological literacy required of Taiwanese students. To assure exact agreement in understanding of terms among the experts, the definitions of terms as well as six rubrics for selected assessment tasks of technological literacy were sent to all experts with the questionnaires.

The results of this study—appropriate benchmarks and assessment tasks for assessing technological literacy -- pertain only to technological literacy of ninth graders junior high school students in Taiwan. No attempt was made to make it utilizable for other grade levels, disciplines, or areas.

Although strict criteria for the identification and selection of experts were established, some of the criteria, such as publication, excluded some specialists of technology education from the panel of experts in this study. That was because many teachers or educators in Taiwan have not published because it was not a professional requirement.

Definition of terms

The following terms are used throughout this study. Conceptual definitions are provided here for clarity of understanding.

- **Assessment Tasks:** products of learning such as on-demand tasks, extended tasks, demonstrations, and portfolios used as objects for assessment (Khatrri, Reeve, & Kane, 1998).
- **Assessment**: an educational process to evaluate student performance and, for the purpose of improving teaching and learning, to find the discrepancy between educational objectives and what students have really learned.
- **Authentic assessment**: helping students become engaged with real or plausible

problems, issues, or tasks which enable students to make sense of what they have learned in school and to make a connection to the world in which they live (Martin-Kniep, 2000, p.26).

- **Benchmark:** a point of reference by which something can be measured (TechTarget, 2001). Benchmarks are subjective descriptions of what students must know and be able to do at a particular age, grade or after a particular unit of instruction.
- **Criteria** - guidelines, rules, or principles by which student responses, products, or performances are judged (MAC, 2000).
- **Delphi Probe:** method for investigating alternative ideas with open questions about the topics to be examined in the Delphi study from possible panel members.
- **Delphi Technique:** method for generating alternative ideas without gathering people together into a single location. Ideas were collected and organized, then distributed to the experts, and they are asked to indicate whether they agree or disagree with the results. After this process is repeated a few times, consensus is reached (Dominick, 2001).
- **Performance Assessment -** measurement approaches by which learners display behaviors or prepare products and assessors judge, according to pre-specified standards or scoring rubrics (EVALCTR, 2000). It comprises assessment tasks and scoring methods (Khatrri, Reeve, & Kane, 1998)
- **Performance Criteria**: guidelines, rules, or principles which can be used to judge the quality of responses, products, or performances (Arter, 2001).
- **Performance Indicator:** detailed metrics (measures) that address learning targets

and indicate whether a specific outcome has been achieved (Calstatela, 1999).

- **Performance Standards**: a compilation of performance indicators for a specific course, subject, or curriculum.
- **Performance**: A general description of the degree of competency that reflects a particular standard (Tanner, 2001, p.66).
- **Performance-based Assessments**: "A set of strategies for the...application of knowledge, skills, and work habits through the performance of tasks that are meaningful and engaging to students" (Hibbard et al., 1996, p. 5). The performance-based assessment can measure students' higher-order thinking skills (Husted, 1999).
- **ROC 2000 National Curriculum Guidelines**: the new curriculum standards promulgated by The Ministry of Education of the Republic of China on September 30, 2000. The Republic of China (ROC) is commonly designated as Taiwan.
- **Rubrics:** assessment devices that use clearly specified evaluation criteria and proficiency levels to measure student achievement. (Montgomery, 2001, p.4).
- **Technological Literacy:** skills or competencies necessary to understand, access, use, and manage technology (ITEA, 2000).
- **Technology:** a creative process for solving problem (Mallet, 1997).
- **Test:** a sample of behavior taken under standard condition (Trice, 2000).
- **Traditional Assessment**: Testing methods that include short-answer paper-and-pencil problems, multiple-choice questions, lab notebooks, and computer simulations.

Summary

This chapter describes the background, problem, purposes, research questions, and significance of the study. The problem evolved from the need to identify important benchmarks and assessment methods for technological literacy. The essential benchmarks for ninth graders of junior high schools in Taiwan, as required by ROC 2000 National Curriculum Guidelines, were identified based on the perceptions and consensus of experts. The result of the study can be used to measure effectively technological literacy of ninth graders of junior high schools in Taiwan with the intent to meet the requirements of the ROC 2000 National Curriculum Guidelines.

This chapter also described the assumption, delimitations, limitations, and definition of terms. These explanations are helpful to clearly elucidate the standpoint of the researcher and the characteristics of this study. The findings of this study will provide direction for educational decision makers in Taiwan to improve teachers' recognition of the benchmarks of technological literacy, promote teachers' understanding of assessment tasks, and enhance teachers' abilities to apply authentic assessment and to implement the ROC 2000 National Curriculum.

The next chapter provides the review of literature, giving further information about the background, purpose, and rationale of this study.

CHAPTER 2

REVIEW OF LITERATURE

Literacy makes contributions to the economy in the form of higher worker productivity, income and government revenues, to a better quality of life in terms of reduced poverty, unemployment, crime and pubic assistance. It contributes to improved health and child rearing, and better adjustment to technological changes (HRDC, 1997, p.57). It has more than one definition.

Literacy skills are classified as prose literacy, document literacy, and quantitative literacy, in the field of adult education (IALS, 1995). Literacy can also be classified as "literacy for self-expression, literacy for practical purposes, literacy for knowledge, and literacy for public debate," when corresponding with the social contexts (CGEA, 1997). Additionally, literacy can be categorized as reading literacy, mathematical literacy, and scientific literacy, when the skills were evaluated (OECD, 2000).

Technological literacy, literacy in the field of technology education, is defined as "the ability to use, manage, and understand technology," (TAAP, 1996) and is treated as the most important area of "literacy," with which all students need to be well-equipped (Dyrenfurth & Kozak, 1991). Improving technological literacy can prepare individuals for jobs in technological society, thus strengthening the economy (NAE, 2001).

Selefe (1999) suggests that government, education, industry and business, parents, and ideology play important roles in the development of people's technological literacy. Wood and Dickinson (2000) propose that teachers, principal, and literacy specialists are prominent in promoting students' literacy in a program. When examining the development of technological literacy of students in school setting, the researcher argues that only the technology teachers play a pivotal role.

To equip students with technological literacy, all technology teachers need to be able to answer the questions "how do we know whether students are well equipped with technological literacy?" and "what are the strengths and deficiencies of a student's learning?" Truly, technology educators in Taiwan have found the teaching and assessment of technological literacy to be a great problem (Shi, 2002). Clearly, they met some difficulties in integrating assessment with instruction and curriculum, a condition that exists in modern school systems (McCullough & Tanner, 2001).

Assessments are easily distorted and fail to match learning targets. For example, factual knowledge is easier to test objectively with a multiple-choice test; hence, factual knowledge were tested more, taught more, and studied more. Lower-level performance is tested more often because developing rubrics for it is easier than developing rubrics for high-level skills. In both circumstances, the learning goal is misdirected.

Tanner (2001) argues that those easiest-to-assess behaviors may dictate instruction without regard to whether they are the most educationally valuable outcomes, and hence will trivialize the curriculum. Conversely, the proper adjustment of assessment can drastically change the nature of student-learning activities and support better instruction toward curriculum goals (Brown & Glasner, 1999).

The assessment of learning achievement of students is important to technology teachers in Taiwan. Because student assessment can assist learning, measure achievement, and evaluate program (NRC, 2001), the results of assessment can be reported to parents, can tell teachers whether they really have helped their students learn, and can improve professional status and self-esteem of technology teachers.

In comparison, the institutional assessment, program assessment, and course assessment are not so important to them because in the reality of educational administration in Taiwan, the effectiveness of the program or course seldom affects the occupational security of teachers. In fact, teachers in Taiwan rarely lose their jobs as long as they do not break the law.

Technology teachers in Taiwan are facing a shortage of objective assessment criteria and adequate assessment tools in their instructional practices (Shi, 2002). Most technology teachers overly rely on paper-and-pencil tests and quantitative scoring. They often fail to assess by criteria referencing, especially those teachers in rural areas or those with little teaching experience (Chiang, 2000).

Under this circumstance, identifying all performance indicators or benchmarks of technological literacy as required by the 2000 National Curriculum Guidelines in Taiwan, and developing an assessment instrument to measure student learning achievement against these benchmarks effectively has become imperative to the sound development of technology education in Taiwan.

In fact, a well-developed assessment instrument to assess technological literacy will unequivocally meet the needs of the new ROC 2000 National Curriculum. It can facilitate and benefit the implementation of at least three new regulations in the national curriculum through effective evaluation of technological literacy:

1. The new national curriculum demands multiple approaches in assessment, such as observation, projects, activities, portfolios, experiments, or presentations, rather than paper-and-pencil tests only. The results of this study will lead to a concrete understanding of multiple assessment methods for assessing technological literacy.
2. Starting in 2001, a comprehensive and summative learning achievement test is mandated for all graduates of junior high schools (grades 7-9 in Taiwan) before graduation. This national examination is offered twice a year and uses a multiple-choice, paper-and-pencil test format.
3. Higher level educational institutes are required to implement multiple approaches to the placement of junior high graduates, including application, evaluation, assignments, and recommendations, rather than paper-and-pencil tests only (IDEA, 2002b). For example, the senior high school entrance examination was discontinued in 2001, and a multi-route program to enter senior high school was implemented (GIO, 2001).

Complex contributing factors that are related to the instruction and assessment of technological literacy as required by the ROC 2000 National Curriculum Guidelines in Taiwan, as well as research methods and findings discussed in the literature, were analyzed to build a theoretical foundation for the identification of appropriate benchmarks and assessment tasks. To meet the objectives of the study, this review of literature includes four discussion segments:

1. Technological literacy and the national curriculum in Taiwan.
2. Research related to technological literacy in Taiwan.
3. Research related to benchmarks of technological literacy.
4. Research related to assessment methods for technological literacy.

In summary, without the identification of appropriate benchmarks and assessment tools, the assessment tends to be distorted and tests only factual knowledge and low-level, easily tested performances. Technology teachers in Taiwan are confronting a new national curriculum, and they need a clear understanding of benchmarks and assessment methods to integrate instruction with assessment and to upgrade their instruction.

Technological Literacy and the National Curriculum in Taiwan

The National Curriculum in the Republic of China (Taiwan)

The new ROC National Curriculum was implemented in September 2001 in elementary schools (grades 1-6) and September 2002 in junior high schools (grades 7-9). Following its implementation, the name of the subject area technology education has been changed to "Natural Science and Living Technology."

The missions of the ROC 2000 National Curriculum which are idealistically presented in the curriculum guidelines (ROCMOE, 2001) as "life-centered," "democratic literate," "fulfilling potential," "appreciating multi-culture," and "adapting to the modern world." However, a more realistic conception held by most teachers is that the mission is simply to help all students acquire adequate skills necessary for entering senior high school or to find gainful employment after graduation from junior high school.

The new national curriculum gives more freedom to schools and encourages individual schools to develop autonomous curricula. All elementary schools (grades 1-6) and junior high schools (grades 7-9) should develop their own curricula, using a curriculum committee of teachers and parents, following the ROC 2000 curriculum guidelines (IDEA, 2002a). Therefore, teachers will have more flexibility in developing curriculum, designing instructional textbooks or materials, and controlling their own instruction.

Two constituents of the ROC 2000 National Curriculum are the seven major learning areas (or subject areas), and the 10 basic competencies (i.e., curriculum goals). The seven major learning areas include language, health and physical education, social studies, arts and humanities, Natural Science and Living Technology, mathematics, and comprehensive activities. The ten basic competencies of the ROC 2000 National Curriculum include self-realization and potential development, appreciation and creativity, career planning and lifelong learning, communication and presentation, social concerning and teamwork, cultural learning and international perception, organizing and implementing, technological and information skills, exploration and research, and critical thinking and problem solving (ROCMOE, 2001).

According to the new ROC 2000 National Curriculum Guidelines, the school year has 200 days and is divided into two 20-week semesters, with students going to school five days a week. Schools can have some flexibility in making their own decision about how many periods to assign each of the seven learning areas by the formula: language area should be assigned 20%-30% of learning time, the rest of the areas should be assigned 10%-15% each. The required and flexible periods per week as well as the minutes per period in each grade are shown in Table 2.1. According to this formula, the teaching periods for the course "Natural Science and Living Technology" are calculated and shown in Table 2.2.

	Minutes per Period	Mandated periods per week (For seven learning areas to share)	Flexible periods per week (Each school can decide how to use them)	Periods per week In school days	Total periods Periods per Year (20 weeks per semester)
Grade 1	40 Min.	20	2-4	22-24	880-960
Grade 2		20	2-4	22-24	880-960
Grade 3		25	3-6	28-31	1120-1240
Grade 4		25	3-6	28-31	1120-1240
Grade 5		27	3-6	30-33	1200-1320
Grade 6		27	3-6	30-33	1200-1320
Grade 7	45 Min.	28	3-6	32-34	1280-1360
Grade 8		28	3-6	32-34	1280-1360
Grade 9		30	3-5	33-35	1320-1400
Total periods in nine years (Grades 1 to 9)					10280-11160

Table 2.1: Instructional time allocated to each subject area.

It can be seen in Table 2.1 that the total periods for students to learn from grade one to nine can vary in different schools from as low as 10,280 periods to as high as 11,160 periods per year. Because the mandated instructional periods for the seven learning areas are only 9,200 periods, every school can add some elective courses not restricted to the seven learning areas mandated by the national curriculum.

Teaching time allocated to technology education in Taiwan

"Natural Science and Living Technology," one of the seven major learning areas required by the ROC 2000 National Curriculum, is the course that offers technology education as well as science education to students in Taiwan. In fact, this course is the result of a political compromise between science educators and technology educators in Taiwan. "Living Technology" is the Chinese way of naming a technology course that emphasizes the connection of technology with society and human living.

The new curriculum has created a problem. Because there are no teacher training programs currently in Taiwan offering both science education and technology education, the new course "Natural Science and Living Technology" must be taught by one science teacher and one technology teacher. The allotment of teaching time for both science and technology teachers becomes a quandary.

According to the new ROC 2000 National Curriculum Guidelines, the new course "Natural Science and Living Technology" will occupy 10% to 15% of the total learning time. In other words, it can offer 100-150 periods for third and fourth graders per year, 108-162 periods for fifth and sixth graders per year, 112-168 periods for seventh and eighth graders per year, and 120-180 periods for ninth graders per year, as shown in Table 2.2. The problem is that there is no explicit allocation of instructional time between "science" and "technology." The possible results of the battle between science teachers and technology teachers in the schools may be from 25% to 50% of instructional time allocated to the instruction of technology education (Living Technology), according to interviews with 10 technology teacher educators in August 2001.

	Mandated periods per week (For seven learning areas to share)	MPFST (Mandated Periods per year For "Natural Science and Living Technology" course) (Grades 3-9)	Probable Periods per year for technology education instruction in "Natural Science and Living Technology" course
Grade 1	20	-	-
Grade 2	20	-	-
Grade 3	25	MPFST = 25 * (10%-15%) * 2 Semesters per Year * 20 weeks == 100 ~ 150 periods	MPFST periods * (25%~50%) == 25 ~ 75 periods per year
Grade 4	25	100~ 150	25 ~ 75
Grade 5	27	27 * (10%-15%) * 2 Semesters per Year * 20 weeks == 108 ~ 162 periods	27 ~ 81
Grade 6	27	108 ~ 162	27 ~ 81
Grade 7	28	28 * (10%-15%) * 2 Semesters per Year * 20 weeks == 112 ~ 168 periods	28 ~ 84
Grade 8	28	112~ 168	28 ~ 84
Grade 9	30	30 * (10%-15%) * 2 Semesters per Year * 20 weeks == 120 ~ 180 periods	MPFSL periods * 25%~50% == 30 ~ 90 periods per year
Total periods in 7 years (grades 3 to 9)		760 ~ 1,140 periods for "Natural Science and Living Technology"	190 ~ 570 periods for "Living Technology" instruction

Table 2.2: Number of periods per week of technology education course.

As can be seen in Table 2.2, the instruction periods per year allocated to Living Technology vary greatly based on different estimations. The percentage of assigning instructional time to "Natural Science and Living Technology" and "Living Technology" will be 10% and 25% respectively when pessimistically, or, it may be 15% and 50% respectively when optimistically.

The computer course is not part of technology education in Taiwan

Students have been learning computer knowledge and skills mainly from technology teachers in the United States, but students in Taiwan are not. The educational authority of Taiwan believes that college graduates from computer engineering programs know better and should be able to teach computer literacy better than graduates from technology education programs. Therefore, computer courses are separated from technology courses according to the ROC 2000 National Curriculum. The instructional time arrangement of computer course is shown in Table 2.3.

	Total Periods per week In school days	Total Periods per School Year (20 weeks per semester, 40 weeks per year)	Mandated Total Periods per School Year For computer course	Mandated periods per year for "Natural Science and Living Technology" course)	Conceivable periods per year for "Natural Science and Living Technology" course)
Grade 1	22-24	880-960	-	-	-
Grade 2	22-24	880-960	-	-	-
Grade 3	28-31	1120-1240	20	100~ 150	25 ~ 75
Grade 4	28-31	1120-1240	20	100~ 150	25 ~ 75
Grade 5	30-33	1200-1320	20	108 ~ 162	27 ~ 81
Grade 6	30-33	1200-1320	20	108 ~ 162	27 ~ 81
Grade 7	32-34	1280-1360	40	112 ~ 168	28 ~ 84
Grade 8	32-34	1280-1360	-	112~ 168	28 ~ 84
Grade 9	33-35	1320-1400	-	120 ~ 180 Periods per year	30 ~ 90 Periods per year

Table 2.3: Periods per year, instructional time, allocated to each subject areas.

As can be seen in Table 2.3, the 20 periods per year allocation of the instruction time to computer courses for grades 3-6 is really insignificant. Table 2.3 also shows that among the 1120-1400 total periods per school year, the instruction time allocated to the course Living Technology for grades 3-9 maybe as low as 25-30 periods per year. The low allocation will become a prevailing state of education, judging from the fact that the party of technology educators possesses a comparative low political status in Taiwan. With a low allocation, 25 periods per school year, technology education cannot offer much assistance to the students. In an ideal arrangement, 37-60 periods per year allocated to the course Living Technology for grades 3-9 would be more appropriate.

The changing of course titles for technology education in Taiwan

In the course of the past half century, the course title for technology education in Taiwan has had many names: labor and work, handicrafts, industrial arts, industrial technology, and Living Technology (ROCMOE, 1994), as shown in Table 2.4. The variety of course titles for technology education in the history of China, including the mainland and Taiwan, such as “labor and work,” “handicrafts,” and “industrial arts,” reveals the changing of educational philosophies toward technology education.

Taiwan was returned to the Chinese government after Japanese occupation after the Second World War. When the schools were re-established, the Japanese curriculum was replaced by a Chinese curriculum that was the same as those implemented in Chinese schools on the mainland. “Labor and Work” was the first course in technology education to be offered in elementary and secondary schools in Taiwan. The educational objectives were to equip students with adequate skills and good attitudes to create value by labor or work, for example, by effectively using tools and materials to improve students' living environments.

When	Where	Elementary schools <Grades 1-6>	Junior High Schools <Grades 7-9>	Senior High Schools <Grades 10-12>
1902	Mainland	Graphic Arts (ROCMOE, 1994)	Graphic Arts	Graphic Arts
1912		-	Handicrafts	Handicrafts
1922		-	Graphic Arts and Handicrafts	-
1923		Image Arts & Industrial Arts	_	_
1932		-	Labor & Work	Labor & Work
1945	Taiwan	Labor & Working	Labor & Work	Labor & Work
1955		-	Work & Production	-
1962		-	Industrial Arts	Industrial Arts
1975		Arts and Working	-	-
1996		Fine arts and technology education	-	-
1997		-	Living Technology	-
1999		-	-	Living Technology
2001		Natural Science and Living Technology	Natural Science and Living Technology	-

Table 2.4: The changing of course titles in technology education

From 1945 until 2002, the course titles of technology education in elementary schools, junior high schools, and senior high schools were changed. They were changing from "labor work" to "industrial arts" in 1980s, and then "industrial technology" in 1990s (Lou, 1995), and finally toward "Living Technology." Overall, they were changing the names of their courses in the direction of the American way of technology education.

Fang and Yang (1996) assert that current technology education in Taiwan begins at the junior high. In their view, technology education in elementary schools is just in the beginning stage. This is true because although the 1975 National Curriculum (ROCMOE, 1975) mandated the course "arts and working" in the elementary school curriculum to teach some concepts of technology (e.g., creativity, use of tools and materials), most of the courses are teaching arts and appreciation of beauty in actual fact (Chen, 1998).

Lung Sheng Steven Lee (2000), a leader in technology education in Taiwan, suggests that the new ROC 2000 curriculum has the following characteristics: (a) Technology education is interwoven with science; (b) Curriculum, instruction, and assessment are performance-oriented; and (c) Problem-solving processes are emphasized.

Technological literacy required in the ROC 2000 National Curriculum in Taiwan

Although technology education in Taiwan is mandated in elementary and secondary schools, the course "Natural Science and Living Technology" is only offered in grade 3-9. For first and second graders, technology education is introduced in another course titled "Living." This course is a combination of social studies, arts and humanities, and Natural Science and Living Technology, as called for in the "Outlines of the Nine-year Consecutive Curriculum" promulgated by the ROC Ministry of Education in Taiwan.

In the ROC 2000 National Curriculum Guidelines, the instructional contents of "Natural Science and Living Technology" is classified into eight categories: (a) process skills, (b) awareness of science and techniques/skills, (c) nature of science, (d) development of technology, (e) scientific attitude, (f) thinking skills, (g) application of science, and (h) design and make. These eight competencies can be treated as learning objectives as well as examples of the scientific and technological literacy expected of students in grade 3-9. The eight competencies listed in the national curriculum guidelines is the product of a consensus of expert science and technology educators in Taiwan.

However, problems have occurred. Because there is no pre-service training for the instruction of "Natural Science and Living Technology," there are few qualified teachers (EJE, 2002). The current science teachers cannot teach technology and the current technology teachers cannot teach science. The best possible way to solve this problem has been to separate the course into two parts and assign them to a science teacher and a technology teacher. Consequently, the course "Natural Science and Living Technology" are separated into the two courses, science and technology, which using the same course title.

Science teachers and technology teachers are sharing the above eight categories of instructional contents. Three of the eight categories, which are specifically relevant to technological literacy, are: (d) development of technology, (f) thinking skills, and (h) design and make.

Because there is no explicit set of benchmarks for the above instructional content in the ROC 2000 National Curriculum Guidelines, it is necessary to undertake a study to identify and describe benchmarks of technological literacy in a measurable, outcome-based format and how to make it more easily assessable.

In summary, the course of technology education in Taiwan has been renamed "Natural Science and Living Technology" according to the new ROC 2000 National Curriculum. The new course will be taught and shared between science teachers and technology teachers. The instruction time allotted for this course will be 2.5% to 7.5% of total instruction time, depending on the schools. Technology teachers will teach three out of the eight instructional components of the course: (a) development of technology, (b) thinking skills, and (c) design and make. The computer course was excluded.

Studies on technology education in Taiwan

In general, problems happening in technology education programs encompass the practices that make technology instruction terribly ineffective in ninth grade because students and parents see preparation for entrance examination to high schools as more important (Wang, 2001). Other problems are caused by shortages of money, educational facilities, competent technology teachers (Chang, 1993), and shortage of effective assessment instruments for teaching technology (Hsu, 1994). Furthermore, the technological literacy of elementary school teachers was not satisfactory in the field of information and communication technology, and in the domains "the scope and content of technologies," and "the processes of technologies" (Ni, 1995).

They share the common viewpoint that technology education is so important to people that it should be extended to the college level. They also admit that the great pressure of college entrance exam on students had made the motivation of students to learn technology very difficult.

Research Related to the technological literary in Taiwan

The study of technological literacy in Taiwan began in the early 1990s. Research literature relevant to its assessment of technology education in Taiwan was scarce (Huang, 1994). Although there is no performance standard relevant to technological literacy in Taiwan, technology educators and technology teachers have been using various approaches to study technological literacy needed by students and teachers.

Research papers pertinent to "the assessment of technological literacy" were selected, reviewed, compared, and contrasted. Two databases were depended on for the study, they are the "Educational Review Database" and "National Thesis and Dissertation Database." Most educational research papers of high quality in Taiwan are included in these two databases.

Based on the literature review, five research papers (Table 2.5) that contribute to the classification of technological literacy in Taiwan are briefly discussed as follows:

In an investigation of technological literacy of junior high students in Taiwan, Hsu (1994) classifies technological literacy into four technological systems: information and communication, transportation, manufacturing, and construction systems. Hsu developed a test of technological literacy based on this organization. In reality, the four technologies: information and communication, transportation, manufacturing, and construction have been considered the major content of technology education in Taiwan during the last decade.

Components of technological literacy	Hsu (1994)	Fang and Yang (1996)	Chang (1996)	Chen (1995)	Lee et al., (1998)
Energy and power			X	X	
Transportation technology	X		X	X	
Information and communication technology	X		X	X	
Manufacturing technology	X		X	X	
Construction technology	X		X	X	
Agricultural and biotechnology			X		
The definition, content, domains, and scope of technology		X			X
The concepts and principles of technology			X	X	X
Impacts and influences of technology; the technology and society		X			X
The evolution and history of technology		X			X
The trends of technological development					X
Use of the tools, machines, materials, products, and systems		X			X
Processes and procedures of technology		X			X
Technological problem-solving					X
Decision making of technology					X
To adapt to the changes of technological society					X
Classroom/lab management				X	
Graphic arts				X	
Electronic technology				X	

Table 2.5: A comparison of classifications of technological literacy from five studies.

One more category, “technology and living”, was added by the research center for home economics and Living Technology in Taiwan. It suggests four different categories of technological literacy: technology and living, information and communication, manufacturing and construction, and energy and transportation (RCHELT, 2002).

Two more categories, “concepts of technology” and “biotechnology,” were added by Chang (1996). Chang classified technological literacy into seven technological domains: information technology, manufacturing technology, transportation technology, construction technology, concepts of technology, energy and power, and biotechnology.

Technological literacy needed of Taiwanese students were classified through a different approach by Fang and Yang (1996). They suggest that technological literacy can be classified into five categories: scope of technology, development of technology, process of technology, application and evaluation of technology, and impact of technology.

Technological literacy required of technology teachers in Taiwan were classified by Chen (1995). Chen asserts that these literacy include: technology concepts, classroom/lab management skills, construction technology, manufacturing technology, graphic arts, information technology, electronic technology, energy and power, and transportation technology. Sheng-Fang Chen (1995) presents that “technology concepts” and “classroom/lab management skills,” are important technological literacy required for technology teachers, other than understanding of variety technologies.

Technological literacy were classified into 10 categories in an investigation of the technological literacy of the first to nine graders in Taiwan by Lee et al. (1998). They developed a test based on the assumption that technological literacy comprised of following ten competencies:

(1). Understanding the definition and content of technology
(2). Understanding the major domains of technology
(3). Understanding development of technology
(4). Understanding and predicting future trends in technological development
(5). Understanding the basic principles of technology is based on
(6). Understanding and effectively using the tools, machines, materials, products, and operational procedures of technology systems.
(7). Using technological literacy in the cognitive, affective, and psychomotor domains for problem-solving
(8). Making proper judgment of technology and its products through data gathering, analysis, and induction.
(9). Understanding the impacts of technology on individuals, society, culture, and the environment.
(10). Adapting to changes brought on by technology (Lee et al., 1998).

As can be seen in Table 2.5, the five studies cited above employ quite different classification of technological literacy. Four technologies (information, transportation, manufacturing, and construction) and "concepts of technology" are most widely adopted in their investigations. Some of the aspects of technological literacy implicit in the ROC 2000 National Curriculum, such as "design process," "maintenance and troubleshooting of products and systems," and "technology and other fields of study" were not included in any one of the studies.

Research related to the Benchmarks of Technological Literacy

Definition of technological literacy

In general, the attributes of technological literacy and the learning objectives for its curriculum become the criteria by which to assess the students' learning and progress.

In order to assess students' learning and progress, the attributes, especially the benchmarks of technological literacy, must be identified after delimiting technological literacy.

Because technology education and its curriculum have been developed to promote technological literacy of students (Nelson, 2000, ETS, 1999), technological literacy can be interpreted as the learning outcome of technology education. However, this definition is vague and unsatisfactory.

Defining technological literacy is still a controversial issue in the field of technology education. For example, Hatch (1985) argues that technological literacy is a multi-faceted construct that includes the ability to use tools (pragmatic aspect), understand the problems brought on by technology (civil aspect), and appreciate the meaning of technology (cultural aspect). Dyrenfurth, Hatch, Jones, and Kozak (1991) suggests that technological literacy is a multi-dimensional concept that includes the practical, civic, and cultural dimensions. Harrison (2000) proposes looking at technological literacy from an educational perspective. Middleton and Wheeler (2000) assert that the focal point of technological literacy is students' technological problem-solving abilities.

It is concluded that the definitions of technological literacy can be categorized as: the ability to use computers and other technologies to improve learning, productivity, and performance (Department of Education, 1997); the ability to use, to access, to manage, and to understand technology (ITEA, 1995, p.6); a reference to the intellectual processes, abilities and dispositions needed for students to understand the link between technology, themselves and society in general (technology education working group, 1998); a set of design and problem-solving skills, and the ability to select materials, safely use tools, and fabricate products (TTEA, 2000).

Criteria of developing and stating the benchmarks

Benchmarks are necessary to indicate minimum level of performance required to satisfy the requirements of the learning outcomes for each Grade (NUE, 2001). As early as 1949, learning objectives were urged to be the statements of behavioral changes of students (Tyler, 1949). "Behavioral objective" specifies an observable, measurable behavior to be exhibited, the conditions under which it is to be exhibited, and the criterion for mastery (Kubiszyn & Borich, 2000). Such objectives would be an ideal format for stating the benchmarks of technological literacy, if they could be stated with the correct verbs to describe the expected learning outcomes effectively, were written straightforwardly, and had test items that match the instructional objectives.

Verbs used to describe analysis	Verbs used to describe synthesis	Verbs used to describe evaluation
break down, distinguish, point out, deduce, illustrate, relate, diagram, infer, separate out, differentiate, outline, subdivide,	categorize, create, formulate, compile, design, rewrite, compose, devise, summarize,	appraise, criticize, support, compare, defend, validate, contrast, justify, conclude, interpret,

Table 2.6: Verbs suitable for use in learning objectives. (Kubiszyn & Borich, 2000).

According to Kubiszyn and Borich (2000), verbs which are suitable for use in learning objectives include “build, draw, fix, identify, list, recall, recite, outline, write” and so forth. When writing learning objectives for cognitive domains, especially for describing those mental skills at the levels of “analyze, synthesize, and evaluate,” the verbs listed in Table 2.6 are appropriate.

Criteria for evaluating benchmarks

The principles described above will be the criteria for developing and stating benchmarks. Table 2.7 explicitly exhibits the consequences of relying on well-stated and poorly-stated benchmarks.

A well written performance indicator	**A poorly written performance indicator**
▪ are simple but not too simple	▪ complicated or simplistic
▪ can be audited and validated	▪ difficult to audit
▪ meaningful comparisons possible	▪ measuring the wrong thing to some extent
▪ measured values are improved only by improved performance	▪ measuring relative negotiated values
▪ multiple objectives of compound criteria are mutually consistent	▪ compound criteria with potential inconsistencies
▪ measurement is possible and worth the cost	▪ measurement difficult or costly
▪ level of detail corresponds to the intent of the objective	▪ level of detail differs from the intent of the objective
▪ achievable but not trivial	▪ unrealistically challenging or trivially easy
▪ can be combined consistently with other criteria	▪ measured value or definition may be easily manipulated
▪ measures things we care about	▪ weighting of criteria may not correspond to overall goals

Table 2.7: Criteria for describing benchmarks.
Source: drawing from the material of DOEOFM (1996)

Performance (behavior), condition (context), and criterion (skill level) are three important components of a performance indicator or a benchmark when it is written in the format of a behavioral objective. When developing a performance indicator, the context of the assessment must be considered by asking what condition is most appropriate to allow students to show their competencies. This condition may be a task, project, teamwork, or a problem-solving situation, involving centered on important concepts or skills.

What criteria other than "measurable," "results-oriented," and "outcome-based," can be used to evaluate the benchmarks of technological literacy? How can one evaluate whether a performance indicator is "provocative and suggestive"?

The National Public Health Partnership (2002) presents some criteria for benchmarks as follows:

Valid – measures the condition or event it is intended to measure.
Reliable – produces the sample result when used under identical conditions or for same event.
Specific – measures only the condition it is intended to measure.
Sensitive – reflects changes in the state or event being measured.
Actionable – provides information that allows assessment and decision-making.
Practical – available without extreme effort and when most useful.
Affordable – available at reasonable cost which doesn't exceed its value.
Integrated – capable of being integrated into routine data collection mechanisms (e.g., surveys, administrative collections).
Non-distorting – does not drive organizational effort only to those areas being measured.
Relevant to the needs of potential users.
Provide **early warnings**
Attractive to the media.
Comparable over time (NPHP, 2002b), and
Flexible -- allows for change over time (NPHP, 2002a).

Categorizing Benchmarks to Assure a Balanced Development

The compilation of well-stated benchmarks should support the learning objectives of the "Living Technology." To assure that a group of benchmarks has been well thought out and can motivate students to achieve the learning objectives, a category of benchmarks, which correspond to the overall learning objectives, should be established.

Such a category features the structure of the benchmarks and assures that every important portion of a learning objective has been covered. Without this category, benchmarks may focus on compliance or process rather than outcomes, distort the holistic scoring, or dictate which process must be applied to achieve the desired outcome.

Categorizing the Benchmarks of Technological Literacy

In order to prepare junior high school graduates to live well in a rapidly changing technological society, technology educators need to be equipped with a real understanding of technological literacy. Identifying the benchmarks of technological skills would appear to be the first step in addressing this need.

The content of technological literacy is extensive, and the task of analyzing technological literacy to identify benchmarks is laborious. Under this circumstance, a well-established, reasonable categorization will certainly simplify the process of developing a range of benchmarks for technological literacy.

Existing performance standards of technological literacy and studies of the content of technological literacy have referencing value to solve the classification problem.

Classification of existing standards

The classifications of prevalent competency/performance standards have been of great value as a point of reference for categorizing performance criteria. Some of the classifications are as follows:

1. In the Standards for Technological Literacy, the performance criteria are divided into four categories: "nature of technology," "technology and society," "design," and "the design world" (ITEA, 2000).
2. In National Educational Technology Standards (NETS), Technology Foundation Standards for Students, the performance criteria are divided into six categories: basic operations and concepts, social, ethical, and human issues, technology productivity tools, technology communication tools, technology research tools, and technology problem-solving and decision-making tools (ISTE/NCATE, 2000).
3. Standard #5 and standard #7 of Learning Standards for MST (Math, Science, and Technology) divide the performance criteria into seven categories: technology, engineering design, tools, resources, and technological processes, technological systems, history and evolution of technology, impacts of technology, management of technology, and interdisciplinary problem solving - connections (NYSED, 1996).
4. The Wisconsin's Model Academic Standards for Technology Education, divides the performance criteria into four categories: nature of technology, systems, human Ingenuity, and impacts of technology (WDPI, 1998),

Other relevant standards are scrutinized for learning how to identify and classify benchmarks of technological literacy. These standards include the National Science Education Standards (NAS, 1995), Benchmarks for Science Literacy (AAAS, 2002), National Educational Technology Standards (ISTE, 2000), Standard 5 of Learning Standards for MST (NYSED, 1996), and Principles and Standards for School Mathematics (NCTM, 2000).

Some standards relevant to "standards for technological literacy" have been developed in other countries. For example, "national standards for adult literacy" and "national standards for adult numeracy" were developed in the United Kingdom, and "curriculum, teaching and the national certificate of educational achievement" was developed in New Zealand.

Classifications of Benchmarks in this Study

The classification of benchmarks used in this study was determined with reference to the classifications of standards in the U.S. and Taiwan. Fifteen subcategories of benchmarks, as shown in the right column of Table 2.8, have been determined to match the three categories of technological literacy as specified in the ROC 2000 National Curriculum Guidelines. Although they do not exactly match each other, this further dividing is an effort to move one step forward to explicate technological literacy more precisely.

Categories of “natural science Living Technology”	Categories of benchmarks based on ITEA 2000 standards of technological literacy
Development of technology 1-1. Nature of technology 1-2. Technology and society 1-3. Development of technology	1. The distinctions and scope of technology (STL #1) 2. The concepts of technology (STL #2) 3. Tools, resources, systems, technological processes, and relationships (STL # 3) 4. Technology and society and human living (social, ethical and human issues) (STL # 4) 5. Impacts and influence of technology (STL #5 & #7) 6. History and evolution of technology (STL #6 & #7) 7. Agricultural, medical, and biotechnologies (STL #14 & #15) 8. Energy and power, transportation technologies (STL #16 & #18) 9. Computer and information technologies (STL #17) 10. Manufacturing and construction technologies (STL #19 & #20)
2. Design and make	11. Applying the design process and engineering design (STL #8, #9, & #11) 12. Innovation, problem solving, troubleshooting, R&D, and experimentation (STL #10) 13. Maintaining systems and products (STL # 12) 14. Accessing, using, and managing the technology (STL # 13)
3. Thinking skills 3.1. Problem Solving 3.2. Creative Thinking 3.3. Critical Thinking 3.4. Systems Thinking 3.5. Reasoning	15. Thinking skills

Table 2.8: Classification of technological literacy. (ROCMOE, 2000; ITES, 2000).

As shown in Table 2.8, the learning objectives of “development of technology” are represented by six subcategories. They are “the characteristics and scope of technology;” “the core concepts of technology;” “tools, resources, systems, technological processes, and relationships;” “technology and society and human living;” “impacts and influence of technology;" and "history and evolution of technology." In other words, they are represented by ITEA standards #1 - #7.

Similarly, the learning objectives of "design and make" are represented by eight categories. They are "applying the design process and engineering design;" "innovation, problem solving, troubleshooting, R&D, and experimentation;" "maintaining systems and products;" "accessing, using, and managing the technology;" and "agricultural, medical, and biotechnologies;" "energy and power, transportation technologies;" "computer and information technologies;" and "manufacturing and construction technologies." In other words, they are represented by ITEA standards #7 - #20.

The learning objectives of "thinking skills" are not divided because at the preliminary stage of this inquiry, more than five technology teacher educators in Taiwan affirmed to the researcher that they do not believe a clear-cut division of thinking skills is meaningful to instruction or assessment. In conclusion, the learning objectives of the course "Living Technology" are represented by 15 categories of benchmarks.

Because it has been suggested that "keeping the total number of performance measures down will keep the cost of measuring down" (DOEOFM, 1996), it is expected that the benchmarks of technological literacy will be restricted to 60 items in 15 categories. These 60 items that comprise the benchmarks will be used as the foundation to develop the assessment instrument for measuring technological literacy.

Before sending benchmarks to a panel of experts for examination, 105 benchmarks, formed from 7 items in each of the 15 categories, as shown in the next three sections of this study, were developed as the groundwork for inquiry. The panel of experts made suggestions to modify some benchmarks. At the end of the inquiry, a set of 60 benchmarks of technological literacy was finalized, grounded in the experts' consensus.

All benchmarks of technological literacy which have been identified were listed in the following three sections. The benchmarks are drawn from the STL -- Standards for Technological Literacy (ITEA, 2000) -- and cover all the areas required in the ROC National Curriculum. However, some of the ITEA benchmarks were not used based on the suggestions from the "Tech Ed counseling committee" in Taiwan (see Appendix B).

Benchmarks related to "development of technology" from STL (ITEA, 2000)

1. The characteristics and scope of technology

(1). Interpret how creative thinking and economic and cultural influences shape technological development.
(2). Appraise how corporations can often create a demand for a product by bringing it onto the market and advertising it; support the idea that marketing involves informing the public about a product as well as establishing the product's identity, conducting research on its potential, advertising it, distributing it, and selling it.
(3). Justify the study of technology uses many of the same ideas and skills as other subjects; and the knowledge gained from other fields of study has a direct effect on the development of technological products and systems; defend that technologies are often combined. Various relationships exist between technology and other fields of study.
(4). Support that technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.
(5). Validate that technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.
(6). Criticize the use of technology affects humans in various ways, including their safety, comfort, choices, lifestyles, and attitudes about technology's development and use.
(7). Illustrate how people generate new products and systems through creativity and innovation to meet their needs (ITEA, 2000).

2. <u>The core concepts of technology</u>

(1). Understanding that technological systems include input, processes, output, and, at times, feedback; they work together to accomplish a goal.
(2). Knowing that systems, which are building blocks of technology, are embedded within larger technological, social, and environmental systems. The stability of a technological system is influenced by all of the components in the system.
(3). Understanding what in their world is natural and what is human made, and knowing that new technology is developed to solve problems and change the world around us.
(4). Be able to define technology encompassing past, present, and future developments and provides significant details and examples to illustrate the definition of technology.
(5). Knowing that people's needs and wants lead to the manufacturing of products, and when people's need and wants change, new technologies are developed.
(6). Knowing that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
(7). Knowing that the development and use of technology influence economic, political, social, cultural, and ethical issues (ITEA, 2000).

3. <u>Tools, resources, systems, technological processes, and relationships</u>

(1). Knowing that resources are the things needed to get a job done, such s tools and machines, materials, information, energy, people, capital, and time.
(2). Understand that access to and ability to use tools, materials, and skills limits technological development. Demonstrate the ways that multiple resources (such as people, information, tools and machines, techniques, materials, energy, capital, and time) are used to develop new technologies.
(3). Understand that tools and machines extend human capabilities, such s holding, lifting, carrying, fastening, separating, and computing.
(4). Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.
(5). Knowing that an infrastructure is the basic framework of a system, which includes buildings, services, and installations needed for a government to function, such as transportation, communication, water,

energy, and public information system.

(6). Understand that an open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.

(7). Able to explain how complex technological systems involve the confluence of numerous other systems. Explain how the submarine or airplanes involves communication, transportation, biotechnology, and manufacturing systems (ITEA, 2000).

4. <u>Technology and society and human living (social, ethical and human issues)</u>

(1). Understand that ethical considerations are important in the development, selection, and use of technologies. Describe personal consequences for the inappropriate or unethical use of technology.

(2). Understand that decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.

(3). Understand that technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.

(4). Able to investigate and assess the influence of a specific technology on the individual, family, community, and environment.

(5). Knowing that a number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.

(6). Understand that the transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.

(7). Knowing that social and cultural priorities and values are reflected in technological devices. In other words, meeting societal expectations is the driving force behind the acceptance and use of products and systems. Understand that the management of waste produced by technological systems is an important societal issue (ITEA, 2000).

5. <u>Impacts and influence of technology</u>

(1). Understand that with the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. The alignment of technological processes with natural processes maximized performance and reduced negative impacts on the environment.

(2). Describe the important technology inventions that have had significant impacts on human beings. Knowing that the use of inventions and innovations has led to changes in society and the creation of new needs and wants. Explain how technological inventions and innovations have caused global growth and interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete.

(3). Knowing that technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.

(4). Explains the interrelationships or connections between technologies and describe how technology has affected the environment and society. Be able to investigate and assess the influence of a specific technology on the individual, family, community, and environment.

(5). Explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.

(6). Understand that humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.

(7). Explain that although technological effects are complex and difficult to predict accurately, humans can control the development and implementation of technology (ITEA, 2000).

6. History and evolution of technology

(1). Gather and organize information to create a database of historical events in technology development. Illustrate how technology has evolved throughout human history.

(2). Students will develop an understanding of the influence of technology on history.

(3). Knowing that in the past, an invention or innovation was not usually developed with the knowledge of science. In fact, much science knowledge is being gathered alongside the technological development.

(4). Knowing that making tools and processing new materials from natural materials advance the technology; besides, putting parts together to create systems and cooperating all specialized skill workers to solve sophisticate problems contribute to the modern technology.

(5). Knowing that the specialization of function has been at the heart of many technological improvements.

(6). Be able to identify trends and monitor potential consequences of technological development.

(7). Compare qualitatively and quantitatively the performance of a contemporary manufactured product, such as a household appliance, to the comparable device or system 50-100 years ago (ITEA, 2000).

7. Agricultural, medical, and bio-technologies

(1). Knowing that medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. Medical technologies extend the effectiveness of medical care and increase people's wealth.
(2). Knowing that conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.
(3). Knowing that agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products and in the care of animals.
(4). Knowing that people in unsafe and remote areas can get medical care, such as being diagnosed or getting treatment with telemedicine. Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.
(5). Knowing that the development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.
(6). Knowing that biotechnology has application in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. Knowing that the sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures. Therefore, it is necessary to establish ethical mandates for regulating the incidence of testing and the uses of test results.
(7). Knowing that artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals (ITEA, 2000).

8. Energy and power and transportation technologies

(1). Knowing that power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.
(2). Knowing that energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.
(3). Knowing that power systems are used to drive and provide propulsion to other technological products and systems. Power systems must have a source of energy, a process, and loads.
(4). Knowing that processes, such as receiving, holding, storing, moving,

unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.

(5). Knowing that transportation vehicles made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, must function together for a system to work effectively.

(6). Knowing that transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.

(7). Knowing what technologies are using to conserve the natural energy resources, and what approaches can be employed to use energy more efficiently in daily living (ITEA, 2000)

9. <u>Computer and information technologies</u>

(1). Knowing that the design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.

(2). Knowing that information and communication systems are made up of a source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. These systems can be used to inform, persuade, entertain, control, manage, and educate.

(3). Be able to use computers to access and organize information, or use it in various applications. Use technology to locate, evaluate, and collect information from a variety of sources. Use technology tools to process data and report results.

(4). Be able to communicate observation, processes, and results of the entire design processes, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

(5). Use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.

(6). Use technology tools to enhance learning, increase productivity, and promote creativity.

(7). Use a variety of media and formats to communicate information and ideas effectively to multiple audiences (ITEA, 2000).

10. <u>Manufacturing and construction technologies</u>

(1). Knowing that buildings generally contain a variety of subsystems, such as utilities systems, they are: water, electrical, plumbing, gas, waste disposal, heating and air conditioning, information and communication, as well as component systems, such as foundations, framing, insulation, and lighting.

(2). Be able to design, fabricate models of construction, and work with other classmates in making a planned model community.

(3). Knowing that manufacturing processes include designing products, gathering resources, and using tools to separate, form, combine materials in order to produce products, and servicing of products and systems. Servicing is included because it keeps products in good operating condition.

(4). Knowing that the product design utilizes a broad range of manufacturing processes, such as metal forming, injection molding, rapid tooling, machining, abrasive water jet cutting, and finishing operations.

(5). Be able to follow step-by-step directions to assemble or disassembly a product, observe, and discover how things work.

(6). Understand that: Structures are constructed using a variety of processes and procedures. Structures require maintenance, alternation, or renovation periodically to improve them or to alter their intended use.

(7). Able to explain how products are manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. (ITEA, 2000).

<u>The benchmarks related to "design and make" from STL (ITEA, 2000)</u>

"Design and make" is the second component of the course on "Natural Science and Living Technology." When learning "design and make," students are asked to devise, process, and present their design and make skills through realistic projects and problem solving activities. These skills can be described with the following benchmarks:

11. <u>Applying the design process and engineering design</u>

(1). Knowing that the design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.

(2). Understand that design goals and requirements must be established and constraints must be identified and prioritized during the time when designs are being developed. Knowing that the process of engineering design takes into account a number of factors (such as: safety, function, flexibility, quality, and economic, political, and cultural concerns).

(3). Knowing that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. Knowing that expressing ideas to others verbally and through sketches and models is an important part of the design process.

(4). Knowing that the design processes include (a) defining a problem, (b), researching and generating ideas by brainstorming, (c) identifying criteria and specifying constraints, (d) exploring possibilities, (e) selecting an approach, (f) developing a design proposal, (g) making a model or prototype, (h) testing and evaluating the design using specifications, refining the design, (i) creating or making it, and (j) communicating processes and results.

(5). Knowing that established design principles should be used to evaluate existing designs, to collect data, and to guide the design process. Be able to evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.

(6). Knowing that requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.

(7). Knowing that a prototype is a working model used to test a design concept by making actual observations and necessary adjustments (ITEA, 2000).

12. <u>Innovation, problem solving, troubleshooting, R&D, and experimentation</u>

(1). Explain how technological inventions and innovations stimulate economic competitiveness and how, in order for an innovation to lead to commercial success, it must be translated into products and services with marketplace demand. Explain through examples how some inventions do not become commercial successes. Describe the process that an inventor must follow to obtain a patent for an invention.

(2). Describes and implements basic troubleshooting techniques for multimedia computer systems with related peripheral devices

(3). Knowing that troubleshooting is a problem solving method used to identify the cause of a malfunction in a technological system.

(4). Explain and demonstrate several solutions to a problem or opportunity using technological design, tools, careful planning, experimentation, and testing.

(5). Be able to use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. Design forecasting techniques to evaluate the results of altering natural systems.

(6). Knowing that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.

(7). Knowing that troubleshooting is a way of finding out why something does not work so that it can be fixed (ITEA, 2000).

13. <u>To maintain systems and products</u>

(1). Be able to use tools, materials, and machines safely to diagnose, adjust, and repair systems.
(2). Be able to troubleshoot, analyze, and maintain system to ensure safe and proper function and precision.
(3). Demonstrate the ability to select, operate, maintain, troubleshoot, and dispose of technological devices in the context of a career (e.g., use the tools of accounting in a real or simulated business environment.)
(4). Identify, select, and use appropriate resources to solve problems.
(5). Apply technological concepts and processes to solve practical problems and extend human capabilities.
(6). Understand that maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.
(7). Demonstrate the ability to work safely, efficiently, cooperatively and independently (ITEA, 2000).

14. <u>Accessing, using, and managing the technology</u>

(1). Be able to select and safely use tools, products, and systems for specific tasks.
(2). Be able to use information provided in manuals, protocols, or by experienced people to see and understand how things work.
(3). Be able to recognize and use common symbols, such as graphic symbols, signals, and icons, to communicate key ideas.
(4). Knowing that technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.
(5). Help to manage a group engaged in planning, designing, implementation, and evaluation of a project to gain understanding of the management dynamics.
(6). Describe new management techniques (e.g., computer-aided engineering, computer-integrated manufacturing, total quality management, just-in-time manufacturing), incorporate some of these in a technological endeavor, and explain how they have reduced the length of design-to-manufacture cycles, resulted in more flexible factories, and improved quality and customer satisfaction.
(7). Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget. Knowing that quality control is a planned process to ensure that a product, service, or system meets established criteria (ITEA, 2000).

<u>The benchmarks related to "thinking skills" from STL (ITEA, 2000)</u>

Thinking skills are seen as an element of technological literary because they are essential in solving technological problems. According to the ROC 2000 National Curriculum, thinking skills are grouped into five components: "creative thinking," "critical thinking," "problem-solving," "systems thinking," and "reasoning."

Thinking skills can also be classified as lower-order thinking skills and higher-order thinking skills. Lower order thinking skills generally include memorization of facts and scientific principles, while higher-order thinking skills include interpreting facts, analyzing for bias, evaluating or synthesizing one idea with another, and applying theories to new situations.

Students were asked to record, demonstrate, and explain their thinking skills through realistic projects and problem solving activities.

15. <u>Problem solving, creative, critical, systems and reasoning thinking</u>

(1). Knowing that asking questions and making observations helps a person to figure out how things work. Besides, knowing that the process of experimentation, which is common in science, can also be used to solve technological problems.
(2). Be able to brainstorm people's needs and wants and pick some problems that can be solved by technology and through the design process.
(3). Be able to test and evaluate the solutions for the design problem in relation to pre-established requirements, and then improve the design solutions or refine the design as needed.
(4). Be able to compare, contrast, and classify collected information in order to identify patterns.
(5). Be able to explore the emerging technologies and develop the skills to evaluate their impacts by reasoning and making decisions based on asking critical questions.
(6). Be able to interpret and evaluate the accuracy of the information

obtained and determine if it is useful. Be able to synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.

(7). Knowing that systems thinking applies logic and creativity with appropriate compromises in complex real-life problems and involves considering how every part relates to others (ITEA, 2000).

The above 105 items comprising performance indicators, with 7 items in each of the 15 categories, are tentative constituents of technological literacy expected from ninth graders in Taiwan. The performance indicators were examined, appended, and verified by experts of technology education in Taiwan.

In summary, the attributes of technological literacy as specified in the curriculum become the criteria by which to assess students' learning and progress. Various definitions of technological literacy have been discussed. Aspects of technological literacy include the ability to identify and solve problems, access resources and technology, use, manage, and understand technology, and analyze, synthesize, and communicate about technological processes.

It is intended that the benchmarks of technological literacy being developed in this study were aligned with curriculum goals, so that they can be used as a guide for learning activities and are suitable for performance assessments. The benchmarks, comprised of 105 items with 7 items in each of 15 categories, having been developed for ease of investigation and were sent to a panel of experts in the study.

Research related to the Assessment methods for Technological Literacy

The assessment system in Taiwan

Khatrri, Reeve, and Kane (1998) assert that assessment tasks and scoring methods are linked to create a performance assessment and multiple performance assessments are linked to create a performance assessment system. For that reason, the development of a performance assessment system to measure technological literacy of ninth graders in Taiwan for the course "Natural Science and Living Technology" should be focused on assessment tasks and scoring methods.

The assessment systems in Taiwan historically have aimed to facilitate the reporting of grades to parents directly and to identify those students who are unqualified so that they can be expelled or put on probation. This is because there are notions in Chinese society that schools are responsible to parents for the education of children and educational resources are so scarce that only good students deserve to participate in the educational process. Both students and parents concern themselves with tests/assessment because the results have great significance (e.g., admission to higher levels of education, or even an opportunity to get an education). Actually, the competitive entrance examination for secondary and higher education admission before 2002 (United Daily, 1997), especially the examination selecting government officers, have survived for many centuries because they have served as a channel for upward mobility for underprivileged social groups (Kuo, 1983).

This assessment system in Taiwan has been monopolized by paper-and-pencil tests. All tests in the test bank for the course of Living Technology, built in 1999 by the

Research Center of Home Economics and Living Technology, sponsored by the Ministry of Education in Taiwan, are paper-and-pencil tests (RCHELT, 2002). This is mainly because paper-and-pencil tests are easy to implement to a large group of students and are an easy way to get fast results with apparent objectivity to discourage any possible dispute from parents.

In this way, the assessment system has distorted learning objectives; it forces all students to change their focus from understanding the concepts to memorizing discrete and even obsolete information to get high scores on the tests. Under this assessment system, students are trained to be technicians in taking tests; suffering through lengthy rote learning exercises everyday, and being constantly reminded, coached, herded, or forced by parents, teachers, and friends to study hard and to discipline themselves (Peng, 1993).

Because knowing what to do and actually completing a task successfully is definitely different (McCullough & Tanner, 2001), schools in Taiwan need a better assessment system which puts more emphasis on performance and offers students opportunities to respond critically to information, to apply, or to create something.

To align with the new assessment system, the learning targets should include both content (what students should know) and criteria (what they can do) (McMillan, 2001).

Until recently, junior high students (grades 7-9) in Taiwan have depended on just one test for the decision about whether they would enter high schools. Beginning in the summer of 2002, Taiwan will discontinue the joint entrance examination of all senior high schools and vocational high schools and initiate a multiple-track admission system.

A new test, the Basic Competency Test (BCT), offering twice a year during May and June, was introduced in 2001 for all nine graders in Taiwan. Students can take both tests and use the better score when applying for admission. In the judgment of admission, the score of the joint examination of basic competencies is considered very important (Shong, 2000).

Traditionally, the assessment systems of elementary and junior high schools in Taiwan relied on the paper-and-pencil tests (Chiang, 2000). There were two or three six-week tests and one semester exam, and these tests counted as 75 percent of the grade for the semester. These were all paper-and-pencil tests. Other assessment methods, such as quizzes, evaluation of projects and papers, and teachers' observation count as 25% of the semester grade (ROCMOE, 1998). But the new regulation, from the ROC Ministry of Education allows city governments to make their own decision about the assessment and scoring system (ROCMOE, 2001).

Promotion of Performance Assessments in Taiwan

In August 2001, a new national standard for the scoring and assessment system for elementary and junior high schools in Taiwan was implemented. This standard emphasizes assessment with multiple approaches or performance-oriented assessment. Fifteen assessment methods are listed in this standard: paper-and-pencil tests, questioning, demonstration, performance tasks, projects, design projects, reports, data collection and summaries, appreciation, interview, self-evaluation, peer-assessment, field trips, exercises, and portfolios. Furthermore, paper-and-pencil tests are restricted to twice per semester (even though they still count as 75 percent of the total grade for the semester), and for the remaining 25% of the grade, the teacher is entitled to use other assessment methods (CCJH, 2001).

The reliance on paper-and-pencil testing is so deeply rooted that it is difficult to make a change. In 1995, the educational authority of Taipei tried to promote performance assessments by ordering all elementary schools in Taipei implement every possible assessment method other than paper-and-pencil tests for the first monthly exam (six-week test). The order was withdrawn after the unsuccessful trial of the first monthly exam, mostly because of opposition from the majority of teachers, parents, and administrators of elementary schools in Taipei (Lu, 1999).

Performance assessments are difficult to implement in Taiwan partly because people do not really understand them. Yang (1999) investigated the awareness of performance assessments of elementary school teachers in the central part of Taiwan by survey with questionnaires a sample of 659 teachers from four counties. The results expose the reality that 40% of elementary school teachers do not understand performance assessments and one third of them do not believe that performance assessments are good for motivating students' learning.

The results also indicate that teachers dislike performance assessments. Teachers' perceptions include the following: performance assessments are time-consuming (teachers are heavily loaded with instructional burden); the teachers are unfamiliar with the assessment processes; there are not adequate facilities for assessing a large group of students in the same room; it is difficult to manage the classroom during the assessment;

and parents may disapprove of this new form of assessment because of concern about the objectivity of scoring.

From July to September of 2000, the ROC Ministry of Education employed a program to collect performance assessment plans, scales, or rubrics from all teachers in elementary schools in Taiwan for the purposes to promoting the implementation of performance assessments. All projects were first classified as either summative or formative assessment and then placed into four subcategories: paper-and-pencil tests, performance assessments, portfolio assessment, and comprehensive assessment. All teachers who participated were encouraged with premiums or awards, and the results of acceptable projects were to be published and sent to all elementary schools.

An independent research center was created by the Ministry of Education in 1997 to study curriculum development and assessment. This was a reaction to critiques of the top-down system of the National Curriculum Standard (Lee & Hwang, 1998).

Performance assessments are part of the old practices of testing in ancient China. Assessment tasks, such as riding a horse, archery, and essay tests were used to select military and civil officers more than a thousand years ago. However, the lack of theories of assessment and learning and the apparent fairness of using paper-and-pencil tests in allocating political resources granted the paper-and-pencil tests a monopoly in Taiwan (i.e., Chinese society) until recently. If sound theories of learning and assessment, as well as valid performance assessments, can be developed by means of educational research, then alternative assessment may be accepted by people in Taiwan.

Researches Related to Assessment Practices in Taiwan

Studies on performance, authentic, and alternative assessments

The new assessment methods have been accepted by some teachers, students, and parents in Taiwan. For example, Shi (2002) studied the practice of performance assessment of the course "living" in the first and second grades in Taiwan. Chen (1999) tried to implement performance assessment in the mathematics classrooms of elementary schools in Taiwan. Hung (2002) studied the implementation of authentic assessment in the social studies classes in elementary schools in Taiwan. Their common findings include: objective assessment criteria and assessment tools are insufficient, performance criteria need to be specific and classified by academic level, and performance assessment has been welcomed by more than half students and parents (Shi, 2002; Chen, 1999; and Hung, 2002).

Studies of applying performance assessment in technology courses are sparse. Chiang (2000) investigated the assessment practices of technology education in junior high schools in Taipei. She asserts that technology teachers in Taipei, Taiwan are overly reliant on paper-and-pencil tests and quantitative scoring/grading. During classroom instruction, technology teachers failed to discuss the assessment plan with their students, nor did they assess with criteria referencing, especially those teachers in rural areas or those with little teaching experience. The most important research finding is that all technology teachers in Taipei regard lack of objective assessment criteria and assessment tools as one of the greatest problems in the learning assessment of technology education.

Chen (1999) studied the implementation of performance assessment in mathematics classrooms of elementary schools in Tai-Chung, Taiwan. He measures the effects of the instruction and assessment by using “Traditional Tests Opinion Inventory,” “Performance Assessment Opinion Inventory” and the “Mathematical Performance Test.” He also sent a questionnaire to inquire students, parents, and teachers about the assessment. Chen affirmed that performance assessment is welcomed by students and parents.

Studies on assessment instruments, tests, and rubrics

Assessment tasks include on-demand tasks, extended tasks, demonstrations, portfolios, and unstructured tasks; whereas, the scoring methods include rubrics, teachers' observations, and checklists (Khatrri, Reeve, & Kane, 1998). Technology educators in Taiwan are trying to develop assessment tasks and scoring methods connecting to technological education.

Results of the studies cited above indicate that the majority of technology teachers of primary and secondary schools, including technology teacher educators of colleges in Taiwan, depend mainly on information from paper-and-pencil tests in evaluating students, followed by information from informal observation. Most of them reported a positive attitude toward performance assessment and a need for professional development in the field of performance assessment (Chiang, 2000; Zhang, 1995; Wang, 1999; Yang, 2000; Chen, 1999).

In general, studies related to portfolio assessment in Taiwan have been conducted in the past decade. For example, Lee (2001) studied the development of portfolio assessment of pre-service teachers in Taiwan. Qualitative methods including case study, interview, document analysis, and observation were used to study the development of portfolio assessment. Lee found that portfolios have a positive influence on the development of pre-service teachers. Lai (2001) studied the effects of using portfolio assessment in a chemistry course at a vocational high school in Taiwan. She contended that portfolio assessment could enhance students' learning attitudes, motivation, and reflection ability. Yew (2002) studied the implementation of an electronic portfolio in classroom instruction for 5th graders. A website was established to offer a portfolio exemplar, discussion forum, science projects, and multimedia resources to support students' learning. Yew claimed that the access to the computers is imperative for the success of portfolio assessment.

In conclusion, researchers in Taiwan have attempted to develop some rubrics. For example, Chang et al. (1998) developed an assessment tool that applies data cubes, database technologies that manage and analyze learning logs, and improves the instruction in distance learning systems. Chang (2001) developed an evaluation tool for web-based learning portfolios. Sun (2000) developed a rubric for assessing the teaching performance of biology teachers in junior high schools in Taiwan.

Studies related to rubrics or checklists in the field of technology education compared with other academic fields, such as arts, foreign language, language art, math, music, science, social studies, and wellness, are rare. For example, the following three websites which contain abundant of resource guides about rubrics (each contain more than 30 web sites for variety disciplines), do not contain any rubrics for technology education:

- Rubrics from the Staffroom for Ontario http://www.odyssey.on.ca/~elaine.coxon/rubrics.htm
- WebQuest Rubric. http://edweb.sdsu.edu/webquest/webquestrubric.html
- LAEP Rubric. http://www.corona.bell.k12.ca.us/teach/imag/rubric.html

The scarcity of assessment methods for technology course is also happening in Taiwan. When checking the two educational databases (NIERR and NCL) on January 23, 2002, 22 research papers and 12 theses or dissertations were found related to rubrics for variety courses, but none of them were pertinent to technology education.

Research methods to study the assessment of technological literacy

The research studies pertinent to the assessment of technological literacy have some characteristics in common. Quantitative methods are used more often than qualitative methods. Questionnaire surveys are used predominantly. The majority of researchers apply self-developed instruments instead of standardized instruments (maybe this is due to lack of Chinese versions of standardized instruments). Most research studies are too broad in setting the purposes -- they have included too many research questions in one study. Research studies that are studying the same issue fail to coordinate with each other and supported by former research. Finally, many research studies are successful in their research format or design but mediocre in their thought content.

It can easily be found that the above research studies in Taiwan demonstrate the following conclusions: "questionnaire surveys" are dominant in studies which investigate the condition of programs or course instruction; "interview" and "panel discussion" are used to develop the framework of questionnaires; "tests, inventory, and scales" are frequently used in measuring competencies or skills; “experiments” are used to test or compare the effects of teaching methods, whereas “the Delphi techniques” are mainly used in identifying the content of curricula or the performance level of competencies. When reviewing the data analysis methods of those studies, it is found that the most frequently used descriptive statistical methods were frequency distribution, mean, mode, median, quartiles, quartile deviation, standard deviation, T-test, one-way analysis (ANOVA), the One Way Multivariate Analysis of Variance (MANOVA), and One Way Multivariate Analysis of Covariance (MANCOVAR).

Technology elevates the improvement of research and education in many ways, such as “on-line Interviewing and reporting,” “computer-based communication,” “online/web research,” “web/online courses,” web meetings, web discussion, and e-mail investigation. These technologies have gradually been transferred to Taiwan. Information technologies such as web-based investigation, video recording, and electronic data retrieval are beginning to be applied in research studies in Taiwan. Some modern inquiry techniques, such as web meetings, web discussion, and e-mail investigation have been attempted in the fields of teaching and learning (Tsai, 1999, Liu, 2001, Huang, 2002a), assessment (Huang, 1999), and guidance (Lu, 2000).

Even though quantitative methods, especially questionnaire survey for a large group of people, are dominant in these studies, there are many other techniques that can be used to collect data for research purposes. These techniques can be classified as:

1. Inquiring from or consulting with people using questionnaire surveys, field surveys, interviews, discussion, meeting, forum, and Delphi techniques.

2. Observing and recording with tape-recording, video recording, field notes, observing work/performances, interaction schedules and checklists, and anecdotal records.
3. Analyzing and assessing people's products or documents such as portfolios, photographs and slides, document analysis, and content analysis.
4. Searching literature such as records, databases, the Internet.
5. Manipulating and controlling environments and research subjects in experiments and tests.

Among these techniques, certain characteristics of the Delphi technique make it appropriate for this study:

1. The Delphi technique is widely used in educational research for gaining stakeholders' views (Lee, 1999) and is of value in identifying performance problems and assessing needs (Lang, 1998). Moreover, businesses, governmental agencies, and organizations also use Delphi methods to predict or forecast future events and relationships (Ludwig, 1997).
2. It is an effective and inexpensive method to generate ideas, because participants can save the time and money that would be required for travel. One result of the cost effectiveness and time reduction realized with the Delphi method is that it is easier to get people involved. Besides, studies can benefit from subjective judgments (Linstone & Turoff, 1975).
3. The anonymity, use of statistical analysis, and feedback of reasoning of the Delphi technique allow participants to think and express themselves under

minimum social pressure and thus present their true conception (Lang, 1998). The anonymity of responses can also avoid the bias of dominant individuals (McNeil, 2001).

4. It allows group communication among experts who are geographically dispersed to build consensus (Ziglio, 1996).
5. Both performance criteria and benchmarks are qualitative in nature, and should not be studied in a quantitative way.
6. The professional judgment of the performance criteria and benchmarks by experts is much more significant than that of ordinary people.
7. The Delphi technique is a systematic method for eliciting expert opinions (Sackman, 1974); it is also the simplest technique for exploring expert opinion (Joel, 2001). Additionally, it is time efficient, because distance and the schedules of experts make meetings difficult.
8. Experts can express their ideas more freely when other professionals are not in close proximity.
9. E-mails were utilized to facilitate the three-round Delphi process because it is an efficient and effective maneuver for the researcher to communicate with and to collect data from experts in widely scattered areas.
10. A minority report about non-important benchmarks viewed of panelists were included in the final report of the study, with the purpose to give a summary of comments made throughout the Delphi processes that were either not included in the recommendations or disagreed with their recommendations.

By so doing it will help validate the development of a performance assessment system by using Delphi technique.

11. Decisions were made in consultation with stakeholders during the preparation stage of the study. Instruments used in the Delphi study were validated and their reliability established by testing content validity and by pilot testing before use in the field.

The Delphi technique certainly has some disadvantages, such as requiring a commitment from participants, the difficulty of defining and locating a panel of experts, and lengthy data collection time frames (Synder-Halpern et al., 2000)

Synder-Halpern et al. (2000), in a study comparing mailed vs. Internet application of the Delphi technique for clinical information research, asserted that using the Internet approach for implementing the Delphi technique could save time and money compared with the traditional mailing approach, but response rates in the e-mail study were 20-40% lower than for the mailing study.

Three critical issues in the process of developing the Delphi study are the number of experts in the panel, the number of rounds in inquiry, and the number of questions in the questionnaires. In regard to these issues, Ludwig (1997) suggests that 15-20 respondents are enough in a panel, Altschuld (1993) suggests that three rounds is enough for the inquiry, and Synder-Halpern et al. (2000) states that 25 is a good upper limit for the number of questions in a questionnaire.

Care should be taken in the process of the Delphi technique to: show the distribution of the group’s responses and give more information than a simple consensus statement (Pope and Mays, 2000); encourage participants to comment on the rationale behind the rating and to add additional items (Ludwig, 1997); avoid inserting moderator opinions into panel feedback; explore areas of disagreement; plan enough turnaround time between rounds, and avoid over generalization of results (Synder-Halpern et al., 2000).

Consideration about cultural difference in research

The legitimacy of applying theories, ideas, or practices emanating from or transplanted to other places with different cultural contexts is questionable (Dimmock & Walker, 2000). When planning research, designing a questionnaire, or asking a question, care must be taken to allow for cultural differences. Only through careful consideration can truth and reality be unveiled by research.

There are cultural differences between people in U.S. and Taiwan (McDaniel & Soong, 1981). Therefore, when inquiring Chinese in Taiwan, all questions of the inquiry in this study were printed in English with Chinese interpretation. This is being done to eliminate the possibility of participants misunderstanding the questions in English and their cultural implications.

In summary, research concerning the assessment of technological literacy in Taiwan is insufficient. Many relevant research studies about curriculum content, learning outcomes, competency of teachers and students, assessment tools, and research methods being used have been collected and summarized in this section. The results reveal that neither performance standards nor standard tests of technological literacy have been created in Taiwan. Most of the classroom assessments and competency evaluations in the field of technology education still rely on traditional paper-and-pencil tests or questionnaires. However, Delphi techniques are widely applied in studying curriculum and competencies.

The need for a performance assessment system for Living Technology

In this study, information was gathered primarily from students because the purpose of assessment is to assess learning rather than assessing the program or the curriculum. Information from students will indicate their learning achievement or progress toward the learning targets. This information can be gathered by using traditional paper-and-pencil tests, performance assessment, assignments, presentations, or other inquiry methods such as observation, discussion, interview, or survey. The purpose is to assess achievement of the objectives, whichever format is used (SASKED, 2001).

Two common classifications of tests are norm-referenced tests and criterion-referenced tests. A norm-referenced test compares student's performance to a norm of a group of students, while a criterion-referenced test compares a student's performance with a criterion or absolute standard. Both norm-referenced (psychometric) and criterion-referenced (performance) assessments can reflect the sequential mastery learning theory, which involves breaking student learning down into disciplines and competencies, removing them from the context that gives them meaning (Latting, 1992).

Criterion-referenced tests can better explain students' technological literacy than norm-referenced tests, because they can more explicitly portray individual performance. Therefore, the performance assessments in this study were criterion-referenced and students' performances in the tests were compared with the benchmarks that are developed in the first stage of the Delphi studies.

In recent years school learning has changed in a variety of ways, moving from whole-class to small-group instruction, from lecturing to coaching and facilitating, from competitive to cooperative learning (Forcier, 1999), and from traditional paper-and-pencil tests to performance assessments (Stiggins, 1994).

Performance assessment is based on the theory of constructivism, which is derived from cognitive psychology (Fosnot, 1996). The constructivist paradigm for approaches to teaching and learning is based on the work of Bruner, Piaget, and Vygotsky (Chen, 2002). Constructivist learning environments should provide multiple representations of reality, encourage thoughtful reflection on experience, and emphasize authentic tasks in a meaningful context rather than abstract instruction out of context (Jonassen, 1994). Genuine technological literacy can only be developed in the context of real systems and problems that have meaning for students. (Liao, 1998)

Schools use assessment to determine how well they are meeting instructional goals and how to alter curriculum and instruction so that goals can be better met. Unless the content and format of assessment match what is taught and how it is taught, the assessment results are meaningless. Montgomery (2001) asserts that practitioners should appropriately match assessment with instruction and curriculum. In order to change assessment to match instruction, some schools rely more upon performance assessment (Porter, 1995).

Performance assessment relies on teacher observation and professional judgment to draw inferences about student achievement. Educators have begun to embrace the reality that some learning targets, like complex reasoning, skill demonstration and product development, require the use of subjective, judgmental means of assessment (Stiggins, 1994). In other words, with performance assessment teachers can acquire information about the extent to which the specified criteria have reached, and students can comprehend their performance deficiency so as to improve their performance (Moskal, 2000).

Based on this reasoning, it is the goal of this study to identify benchmarks and assessment tasks for the course “Living Technology” to help both teachers and students by facilitating their teaching, learning, and assessment, and to support professional development and program evaluation (ITEA, 2003). Moreover, the study seeks to introduce authentic assessment to technology teachers, to help them go beyond the concept that the primary purpose of assessment is determining grades and the primary tool is a test (NASSP, 2002), and shift away from traditional assessment methods. A strategy that limits the proportion of traditional multiple-choice tests to a minimum in these performance assessments was employed.

Research related to the assessment tasks and performance assessment

Characteristics of performance assessment

Assessment is a tool to understand the strengths and weaknesses of the instruction, to check the students’ learning progress, and to stimulate and enhance student’s learning.

Aspects of performance assessment include performance criteria, performance exercise, scoring and recording, and assessing in a guidance context (Stigins, 1994).

When it is planned, a performance assessment should be integrated into instruction and linked to content and performance standards (Khatrri, Reeve, & Kane, 1998). The distinct traits of performance assessment are that students construct rather than select responses, assessment tasks reflect real-world requirements, and scoring reveals patterns in students' learning and thinking (Fuchs, 1995).

Desirable characteristics of performance assessment instruments include direct assessment of behaviors, subjectively scored, standardized, consisting of a wide range of instruments, and integrated, criterion-referenced, and externally scored (Latting, 1992). A well-designed assessment measures important learning outcomes, addresses all purposes of assessment, provides clear and specific descriptions of student performance, is compatible with instructional models, is easily administered, scored, and interpreted, communicates the goals of learning to teachers and students, and generates accurate, meaningful information (Fuchs, 1995). The criteria of assessment were adopted as a direction for the study.

Performance assessment were promoted in the study because the potential benefits of performance assessment may well warrant its relatively high cost because it better integrates assessment and instruction, focuses on higher level thinking skills, provides greater motivation for engaging in instructional activities and preparatory study, and enhances instructional and content validity (Crehan, 1991).

Procedures of developing performance assessment

The procedures for developing an assessment program, synthesized from the book Assessing Adult Learning: A Guide for Practitioners are to first determine the learning targets, learning activities, and learners' behaviors and progress, decide on assessment tasks and tests, decide on the methods of scoring and interpreting the test results, and consider how to involve informal assessments (Moran, 1997).

There are four steps to assessing learner outcomes, as presumed by Priestley (1985): to determine assessment purpose, identify resources, decide whom to assess and when, define what to assess, decide how to assess, create a preliminary plan, and evaluate the plan; interpret the learner outcomes or learning objectives in terms of what is to be measured; select assessment instruments -- interpreting the learner outcomes helps to determine what type of assessment methods should be used to measure specified skills and content; and determine which assessment method to select.

Kubiszyn and Borich (2000) argue that performance tests can assess processes and products, can be embedded in lessons, and can assess affective and social skills. Performance test methods include hands-on exercises, problem solving, observation of students' processes, or observing achievements, mental habits, ways of working, and behaviors of value in the real world.

The authors also assert that the procedures for developing a performance test include creating specific performance indicators or outcomes of instruction and arranging a situation or condition that allows learners to demonstrate their learning achievements. Finally, they suggest that the task or situation should center on issues, concepts, or problems that are important to the learning context. The criteria for revising and refining the task include the following:

- The requirements for task mastery should be clear without revealing the solution.
- The task should represent a specific activity from which generalizations about the learner's knowledge, thinking ability, and habits of mind can be made.
- The tasks should be complex enough to allow for multi-modal assessment.
- The task should yield multiple solutions where possible, each with costs and benefits.
- The tasks should require self-regulated learning (p.168).

The concepts discussed in "procedures for developing performance assessment" were used to guide the study in the design and construction of the one holistic and three analytic performance assessments for "Living Technology." When developing performance assessments, students should be involved in interpreting the evaluation criteria and making the criteria clearer and more meaningful (Montgomery, 2001). However, students need not be involved in developing criteria and selecting model responses if they are more comfortable having scoring criteria provided to them (Ferrara, 1995).

The design and construction of performance assessments

The design and construction of performance assessment in the study will determine assessment tasks or tests, decide on the scoring for each task, decide on the content areas to be covered in each task, and develop assessment instruments. Performance assessments come from a variety of sources, including teachers' observation, inquiry from students, peers, or parents, testing of students, examining students' products or performance, and inspecting students' writing or records.

Kubiszyn and Borich (2000) assert that students' learning outcomes or accomplishments can be categorized as products, observable performance, complex cognitive processes, habits of mind, and social skills. Among these, products and observable performances are more easily scored than others when scoring with checklists, rating scales, holistic scales, or rubrics.

The six types of performance assessments are two-step problem solving with student constructed responses, short, dichotomously scored answers provided by students, short answers, essays, and thought experiments, in which nature of the response is up to students, paper-and-pencil simulations that realistically mimic the actual environment, simulations in realistic environments, and evaluation in the actual environment (Finch & Dost, 1992).

Numerous alternative assessment methods include actual performance, simulations, observational assessments, oral assessments, paper-and-pencil assessments, and forms of program requirements designed to assess prerequisite skills or knowledge in a non-testing context (Priestley, 1985). Alternative testing can be classified as performance testing, discourse testing (oral and written), documentation practices or student work samples (portfolios and exhibitions), and records kept about those samples (Hill & Larsen, 1992).

In the classroom setting, an assessment using an outcomes focus can provide evidence of students' learning achievements through the following methods: observation, teacher journals, checklists and matrices, criterion referencing, self-assessment, peer assessment, open-ended tasks, student-teacher conferences, teacher-made tests, standardized tests, monitoring standards in education, student journals, portfolios, Individual Education Programs (IEPs), negotiated evaluation, and on-balance judgments (ARCA, 2000).

Assessment tasks

The objective of utilizing assessment tasks is not to produce remarkable products, but rather to enlighten students' growth and achievement. A variety of assessment tasks or tests can be used to evaluate the students' performance, such as paper-and-pencil tests, essays, oral presentation, projects, portfolios, logs, journals, and track records, anecdotal records, computerized assessments, video and audio tapes, adaptive testing, work sample tasks, work simulation tasks, questionnaires, observations, interviews, the critical incident technique, and others (Wheeler, 1993).

Other researchers suggest other assessment approaches such as paper and pencil tests, group discussions, simulations, work samples, and content analysis (Neely and Schuley, 1978). Campbell et al. (1997) in the book, How to Develop a Professional Portfolio: A Manual for Teachers, introduce the following possible assessment tasks:

Unit Plans,
Evaluations,
Projects,
Anecdotal Records,
Curriculum Plans,
Article,
Summaries of Critiques,

Awards and Certificates,
Meeting and Workshop Log
Lesson Plans,
Assessments,
Bulletin Board Ideas,
Position Papers
Field Trip Plans,

Self-Assessment Instruments,
Research Papers,
Problem-Solving Logs
Individualized Plans,
Essays,
Case Studies,
Community Resources Documents,
Media Competencies,
Teacher-Made Materials,
Schedules,
Rules and Procedures Descriptions,
Floor Plans,
Peer Critiques,
Computer Programs,
Strategies
Goal Statements,
Video-Scenario Critiques,
Simulated Experiences,
Seating Arrangement Diagrams
Philosophy Statement,
Cooperative Learning,
Theme Studies,
Work Experience Descriptions,
Student Contracts,
Journals,
Portfolio (Student),
Volunteer Experience Descriptions,
Professional Development Plans,
Interviews with Students, Teachers, Parents,
Professional organizations and Committee List,
Classroom Management Philosophy,
Observation Reports,
Subscriptions,
Professional Readings List,
Management and Organization Strategies,
Letters to Parents,
Transcripts,
Pictures and Photographs,
(Campbell et al., 1997)

Students' learning products include individual reports, essay writing, written projects, student journals, design projects, portfolio, and so forth. Students' observable performances are outcome-based, clearly delineated behavioral objectives such as presentation, participation in-group projects, class participation, and test performance (Biggs, 2000).

Students' projects are assignments that involve problem solving, group presentations, creating materials, investigating phenomena, or researching current information (Campbell et al., 2000). Additionally, all design and make assignments of technology courses in Taiwan are projects (ROCMOE, 2000).

To determine the assessment method most appropriate for a given performance evaluation system, it is necessary to consider purpose and criteria, as well as individuals, resources, and legal and technical issues (Wheeler, 1993). Besides, assessment methods should be used in a variety of ways to measure different learning outcomes and to accommodate different learning styles, different ways of displaying learning, and the nature of abilities being assessed (Saskatchewan Education, 1991; SACE, 2002). Five dimensions of assessment tasks -- time demands, applied problem-solving skill demands, meta-cognitive demands, social competencies, and student control -- should be taken into account (Khatrri, Reeve, & Kane, 1998).

Because the performance assessments developed in the study are summative assessment in nature, some of the assessment types listed above, such as student self-evaluation, peer-evaluation, group discussions, and simulation may not be appropriate. Furthermore, practical reasons such as cost, time, resources, and technical considerations will hinder the utilization of the following assessment tasks in summative assessment: anecdotal records, computerized assessments, video and audio tapes, adaptive testing, work sample tasks, work simulation tasks, questionnaires, interviews, the critical incident technique, and other informal assessments.

Classification of assessment methods

Assessment methods can be classified in a variety of ways. For example, they can be classified as test-centered performance assessments, which focus on a specific skill, and construct-centered performance assessments, which focus on a domain of skills (Khatrri, Reeve, & Kane, 1998). They can also be classified as controlled-response tests, open-ended questions, and performance tasks (McCullough & Tanner 2001). They can be classified as four types as suggested by McMillan (1998): selected-response, constructed-response, teacher observation, and self-report inventories. McTighe and Ferrara (1997) asserted that assessment tasks could be classified as students' responses (selected or constructed), products, processes, or performances.

Some of these terms are mutually exclusive, such as "on-demand tasks and extended tasks" as well as "selected-response and constructed response." Some of them are similar in meaning such as "open-ended questions and constructed-response" and "controlled-response and selected response." Synthesizing from the variety of classifications listed above, an operationally adequate classification of assessment methods, which has three categories -- test-oriented, task-oriented, and inquiry-oriented, was developed by the researcher, as shown in Table 2.9.

<table>
<tr><td colspan="3">Comparison of three categories of assessment methods</td></tr>
<tr><th>Test-oriented</th><th>Task-oriented</th><th>Inquiry-oriented</th></tr>
<tr><td>On-demand tasks</td><td>Extended tasks</td><td rowspan="4">Assessing by inquiring</td></tr>
<tr><td>Controlled-response</td><td>Constructed-response</td></tr>
<tr><td>Selected-response</td><td>Open-ended questions</td></tr>
<tr><td>Task-centered</td><td>Construct-centered</td></tr>
<tr><td>Examples:
Multiple choice
True or false
Oral presentation
Essays (restricted-response)</td><td>Examples:
Projects/product exhibition
Portfolios
Design and problem solving logs
Performance tasks</td><td>Examples:
Teacher observation
Self-report inventories
Questionnaire survey
Interviews
In-class case study
Questioning</td></tr>
</table>

Table 2.9: Kung-Fu's classification of assessment methods.

The test-oriented assessment methods assess students on demand and mostly with controlled response, questions using paper-and-pencil or computer-assisted tests. Task-oriented assessment methods assess students with extended tasks and evaluate both the processes used and the results. Inquiry-oriented assessment methods assess students with inquiry techniques including observation, survey, and self-report.

Among those generally used assessment tasks, multiple-choice tests, essays, or research papers, true and false tests are "test-oriented," projects/exhibition, portfolios, journals or logs are "task-oriented," while questionnaires, interviews, and teacher observation are "inquiry-oriented." All of the three types of assessment tasks were used in the study.

Rationale in designing analytical and holistic tests

Rubric is a general term for an assessment instrument. A holistic rubric provides one score or rating for the entire product or performance, whereas, analytical rubric includes several scores or ratings for a particular product or performance (Arter, 2001, p.25). When using rubrics in the assessment of technological literacy, the domains of technological literacy should be determined beforehand.

Technological literacy was classified as having three domains: "development of technology," "design and make," and "thinking skills," according to the ROC 2000 National Curriculum Guideline. To effectively assess all phases of a student technological literacy, technology teachers in Taiwan need both holistic and analytical assessment instruments to evaluate technological literacy. The rationales in choosing analytical tests and holistic tests are compared in Table 2.10.

Rationales for Designing Analytical Tests	Rationales for Designing Holistic Tests
Multiple approaches in assessment Integrated with instruction: implementing during classes For grade 3 to 9, during the learning. Tasks: extended tasks (projects, papers), portfolios, demonstrations, or tests. School level examination: administering and supervising by school principal Test authentically, all term paper, projects, or design projects of students can be used in the tests. The results of tests can be presented both in quantity and quality, although qualitative description of learning achievements will be presented with the help of new design rubrics. To infuse technological knowledge and design activities in the technology classroom instruction.	Multiple approaches and integrated curriculum should be adopted in the assessment. Implementing at the end of a semester or academic year. For grade 8 or 9, after finishing the learning of a category of technological literacy. Tasks: on-demand performance tasks District-level or County-level examination: administering and supervising by local educational authority Test objectively, all students projects and papers can not be used To fit the scoring system in Taiwan, results of tests are presented in score with maximum of 100, although the scores of different categories of learning will be also presented. The numbers of open-ended questions should exceed those closed-ended questions in the test.

Table 2.10: Comparison of analytical tests and holistic tests.

<u>The six proposed assessment tasks</u>

Although there are more than 50 types of assessment tasks, some are more suitable to formative assessment than summative assessment. After judging a variety of factors, six promising assessment tasks/methods for use in this study were selected. They are multiple-choice, essay tests, oral presentation, project/exhibition, teacher observation, and portfolios. They are analyzed in terms of their advantages in Table 2.11. They were sent to a panel of experts in the Delphi studies, and are briefly discussed below.

Advantages of assessment tasks	Assessment Tasks/Methods					
	Multiple Choice	Essays/ Papers	Oral Present-ation	Teacher observ-ation	Project/ Exhibition	Portfolios
Evaluation or grading	X	X	X	X	X	X
Diagnosis of student strength and problems	X	X	X	X	X	X
On-demand tasks	X	X	X	X		
Extended tasks					X	X
Formative feedback and evaluating students' attainment and progress in the subject						X
Relevant to meaningful learning of subject-content		X	X	X	X	X
Measuring focus on ability to organize ideas and concept construction		X	X		X	X
Motivation of performance			X	X	X	X
Corresponds closely with benchmarks		X	X	X	X	X
To use higher thought processes		X	X		X	X
Embedded in a meaningful context that seems authentic		X	X	X	X	X
Conveys a sense of fairness to all	X					
Controlled-response or selected-response	X					
Open-ended questions or constructed-response		X	X	X	X	X

Table 2.11: Classification of Assessment Tasks.
Sources: (McCullough & Tanner, 2001; McMillan, 1998; Khatrri, Reeve, & Kane, 1998; Campbell et al., 2000; Cangelosi, 2000; Glatthorn, 1998; and Montgomery, 2001)

The traditional multiple-choice test has been prevalent because it is time-saving, easy to prepare, easy to grade/score, can be used to test a large number of people at the same time, and is ideal for testing rote learning. Some disadvantages of the multiple-choice test are that it can only measure factual knowledge or limited application of facts, and it is ineffective as a test for thinking skills. As a selected-response test, the multiple-choice test cannot measure important learning outcomes, such as communication skills, physical skills, reasoning skills, and applying knowledge in "real-world' situations (Arter, 2001).

Educators criticize the multiple-choice test mainly because it forces the teaching and learning to focus on specific facts from a course, while they realize that only concepts, principles, and major themes can be really helpful in dealing with problems encountered in daily living. The major advantages of the multiple-choice test are that it is easy to score and it can sample a large number of learning outcomes efficiently. However, performance assessments are more content valid and thus are increasingly being used to observe concept acquisition and skill development in reading, writing, and mathematics (Grehan, 1991).

Furthermore, performance assessments can be natural parts of the instructional setting and can assist students in motivation and preparation. Arter (2001) argues that the “selected-response test” (e.g., multiple-choice) is not more objective than performance assessment because “subjective judgments enter all the way through the development of selected-response questions” (p. 2).

The traditional multiple-choice test will still be included among the performance assessments in the study because it has definite value in measuring factual knowledge, and because it can play a complementary role alongside with new performance assessments (Moran, 1997). Although an essay test is poor in evaluating skills and products, it can document almost any standard (Campbell et al., 2000), can measure understanding and the ability to synthesize and evaluate, and can be used in both formative and summative assessment (SASKED, 2001).

Kubiszyn and Borich (2000) state that strategies to improve the scoring reliability of essay tests include structuring good essay items by using several restricted range items rather than a single extended range item, use of a predetermined scoring scheme, implementing the scoring scheme consistently, removing or covering names on papers to avoid scoring bias, scoring all responses to one item before scoring the next item, keeping scores from previous items hidden when scoring subsequent items, re-scoring all papers before returning them, and averaging discrepant ratings (p.127).

Oral presentation and multimedia presentation are used in performance tests to present learning outcomes, findings, knowledge gained, or information about the learner's project. For group projects, each student must make an individual oral presentation. The oral presentation is evaluated on the basis of public speaking skills, content knowledge and analysis. Teachers can use rubrics to justify their rating of basic, proficient or advanced use of language (ETI, 1997).

When students' technological literacy is evaluated by oral presentation, the content (what is said) and execution (how the content was organized and presented) are two key elements of proficient demonstration of performance. These two performance traits need separate assessment criteria for their evaluation. Teacher observation is a straightforward way to assess performance while students are engaging in an activity or working on a project (Marzano, 1997). The recording of teaching observation can be either high inference or low inference. “High reference” means judgments are made based on performance criteria by using a checklist or a rubric, whereas, “low reference” means specifics of the performance and critical incidents are described without placing a valuation on them. The low inference way of recording is more objective and more “closer-to-the-event, ” while; the high inference way of recording is more efficient in obtaining the result of assessment (Maxwell, 2001).

The instrument used in teacher observation is called “teacher observation form” or “rubrics for teacher observation.” With a rubric or teacher observation form, evidence of specific learning outcomes on particular occasions can be effectively recorded, interpreted, and measured.

Projects in technology courses include problem solving, design, research, presentation, or exhibition; they are useful for summative assessment because the result of projects can demonstrate students’ skills and knowledge. Projects should be related to benchmarks and involve hands-on application of skills so that students can explore a topic in depth and use a range of process abilities (Christensen, 1995).

Projects can be done by a group of students. For evaluation, individual student responsibilities should be clearly spelled out in group plans. Using student self-assessment is another avenue for determining individual contributions and participation (SASKED, 2001).

Teachers assess student projects as basic, proficient or advanced based on the project plan, evidence of progress, and the final product (ETI, 1997). They can also examine the performance criteria to determine if the project reflects the ability to meet individual needs, or knowledge of content (Campbell et al., 2000). Teachers can provide guidance on the projects such as scheduling frequent deadlines, requiring weekly progress reports, and designating special project days.

A portfolio is a purposeful collection of student work that demonstrates student effort, progress, and achievement. Students participate actively by providing input, reflection, and self-evaluation (California Department of Education, 1995).

When producing portfolios, students actively collect and reflect on their work and decide what work is representative of growth (Seven Oaks School Division, 2001).

The format of the works in the portfolio may vary and include such forms as video-tapes, audio-tapes, written work, drawings, paintings or photographs, journals, reaction letters, research papers, self-evaluations, tests, drafts, journals, projects, problem-solving logs (NCRVE, 1995), and other types of work (Curriculum Frameworks Project, 2000). Possible collectibles include homework, teacher-made tests, learning logs and journals, written artifacts, videos of performances, audio cassettes of speeches, readings, questions, songs, interviews with students, observation checklists, self assessments, goal statements, work in progress, artwork, lab experiments, problem solving logs, and best work.

Performance assessment can free the teacher from the constraints of standardized tests or traditional paper-and-pencil tests. The application of portfolio assessment can change classroom practices to meet the developmental needs of children, and it to compare current work to earlier work and indicate students' progress toward developmental expectations (Grace & Shores, 1991). Moreover, utilization of a portfolio leads to self-reflection, motivation, higher- cognitive skill development, integration of skills, and enhanced student performance (Robinson, 2000).

The content of a portfolio can be organized by category of development and then by chronological order (Grace & Shores, 1991). Contents of a portfolio can include the following:

- Problem-solving logs made up by a student
- Report of a group project
- Excerpts from a daily journal
- Notes from an interview or conference
- Teacher-completed checklists
- Video, audio or computer generated examples of student work
- Work that shows the student's correction of errors or misconceptions.
- Self-assessment/reflection (LC5EC, 2001).
-

Among all components of a portfolio listed above, keeping logs is a good way to document professional commitment and to help students discover their need for improvement in some areas on their own (NCRVE, 1995; Campbell et al., 2000). Problem solving logs should include the statement of the problem, strategies for dealing with the problem, and the results of the implementation of chosen strategies (Campbell et al., 2000).

Because of their versatile functions, all of the six assessment tasks discussed above (multiple-choice, essay, oral presentation, teacher observation, project/exhibition, and portfolios) were included in the study and presented to the panel of experts for the development of the performance assessments.

The structure of the performance assessment of "technological literacy"

The construction of the performance assessment for holistically measuring technological literacy will include multiple-choice, essay, oral presentation, teacher observation, projects, and portfolios. Although in the ROC 2000 National Curriculum technological literacy has been divided into three categories: (a) development of technology; (b) design and make; and (c) thinking skills, yet it can be more accurately represented by the 60 benchmarks identified in this study.

Types of scoring system/methods

The scoring system best suited for the type of performance being assessed should be determined. Different approaches to scoring include observing and assessing by teachers or evaluators, students' self-evaluation, peer evaluation, video or audiotaping, computer assessment, and informal assessment.

Among these different approaches, self-assessment instruments such as rating scales, inventories, or questionnaires are used by teachers or students to understand their progress, achievement, or performance (APS, 2001). Self-assessments by students or peers may not be appropriate for summative assessment especially for grading because it is difficult to verify the objectivity of assessment.

Three characteristics of the scoring system (i.e., assessment device) of performance assessments are "level of prescription," "scope of pedagogical net," and "technical robustness/features" (Khatrri, Reeve, & Kane, 1998). The "level of prescription" refers to the degree of control teachers have over assessment tasks. The "scope of pedagogical net" refers to how students and teachers are involved in the assessment, and how data is collected from different domains of skills. The "technical features" refer to whether the performance assessments have adopted various procedures to establish validity and reliability, such as development of assessment tasks, inter-rater reliability procedures, development of scoring rubrics, and scoring procedures (Khatrri, Reeve, & Kane, 1998, pp. 48-55).

In general, scoring methods include checklists, scoring sheets, rating scales, holistic ratings, and rubrics. Comparing the usability of the methods, holistic scoring is the easiest to construct and most efficient to score, while checklists have the best reliability, defensibility, and quality of feedback. Additionally, checklists are easy to develop and easy to use.

Comparing them in terms of appropriate utilization, holistic scoring is suitable for products and processes, checklists are suitable for procedures, complex behaviors, or performances, and rating scales are suitable for attitudes, products, social skills (Kubiszyn, & Borich, 2000). Holistic rating is inappropriate for formative assessment because the single, summary evaluation it offers cannot indicate the learner's strengths and weakness (Tanner, 2001).

Rubrics have the strengths of all other assessment methods. Moreover, rubrics do more than check the presence or absence of an attribute, testify that an attribute is worth a given number of points, and inspect the degree of completeness. Actually, rubrics are suitable for assessing all attributes of quality in a process, product, or performance (Martin-Kniep, 2000). The learning outcomes or performance criteria on the rubrics can be used to justify the judgment of student's achievement.

Characteristics of rubrics

Rubrics are descriptive scoring schemes developed by teachers or other evaluators to guide the analysis of the student products or processes (Brookhart, 1999). Rubrics can be used to help teachers assess projects more objectively. The scores from rubrics are highly meaningful to students' learning because the rubrics can provide students with detailed descriptions of their performance outcomes (Moskal, 2000). Rubrics, which are established with student input can set expectations for the quality of learning outcomes as well as the aspects of group work, such as playing roles, completing the tasks, participating in the discussion, and being a supportive group member (Nagel, 2001, p.36). Characteristics of high-quality rubrics include: content, clarity, practicality, and technical quality/soundness (Arter, 2001).

Rubrics can be designed in either holistic or analytic style. Holistic rubrics can assign a single score to an entire product, process, or performance. Although holistic rubrics are easy to use, they are difficult to construct, and fail to indicate specifically what students need to do to improve. Analytical rubrics can only assign a single score to one attribute of a product, process, or performance. Although analytical rubrics are easy to construct, they take a longer time to score because it takes a complete set of analytical rubrics used together to measure the whole performance (Martin-Kniep, 2000).

Strengths of rubrics

Advantages of rubric evaluation over the traditional grading system include the following:

1. Rubrics can fully depict student competencies and learning proficiencies;
2. Rubrics clarify expectations and standards of learning;
3. Rubrics can open constructive conversations among teachers, parents, and students about explicit learning achievements, such as strengths, weaknesses, and deficiencies;
4. Rubrics can equip teachers with better skills in objectively assessing student performance and tasks, broaden assessment processes from traditional factual knowledge to higher level skills, such as projects, group work, or other problem solving activities;
5. Rubrics can help students take responsibility for their own learning and perceive where their work needs to be further improved and refined; and
6. Rubrics have value to other stakeholders (such as parents, administrators, and community members) in letting them know what content has been mastered by the students (Liu, 1995).

Limitations of rubrics for assessment

The drawbacks of using rubrics include: the function of rubrics is restrictive, and some of the outcomes we prize are not directly observable; the manifestation of the traits of higher level abilities (i.e., creativity, analytical ability, comprehension, and problem-solving skills) is difficult (Tanner, 2001); rubrics may not be able to productively focus on the instruction (Neuman & Dickinson, 2001, p.384); when using a rubric, measuring bias may exist if the rubric leaves some room for judgment by different observers/raters, and intra-observer-consistency was a concern (Cangelosi, 2000); some serendipitous learning outcomes are difficult to anticipate or to be totally involved in one single rubric, and that students' learning may be constrained by listed learning outcomes (Maxwell, 2001); and bias may also exist at the stage of designing a rubric.

Design of rubrics

The techniques for defining the different levels of performance for rubrics are as follows. First, clearly identify the qualities that need to be displayed in student's work to demonstrate proficient performance. The identified qualities will form the top level of scoring criteria for the scoring rubric (Brookhart, 1999). Second, the lowest level of performance can be determined by referencing performance standards or discussion with students. Third, the criteria for the middle level or levels of performance can be determined by examining the two extremes (Moskal, 2000).

When designing rubrics, the descriptions of the different levels of performance criteria should be meaningful and easy to understand, and should be a subjective description rather than a judgment about the work (Brookhart, 1999). Because, different contexts impose different conditions, confirmation of the transfer of learning outlined in the outcome to different contexts is basic to an "on-balance" judgment. The curriculum needs to allow for this by ensuring a range of contexts in learning programs and assessments (AOBJ, 2000).

A well designed rubric should be focused on measuring a stated objective (performance, behavior, or quality), used a range to rate performance, and arranged specific performance characteristics in levels to indicate the degree to which a standard has been met (Pickett and Dodge, 2001). A tentative format of rubrics which can effectively illustrate what an assessment task is evaluated is shown in the Table 2.12.

Design of a rubric for essay tests

To summarize, rubrics can be used to make the expectations for learning and assessments clear. In fact, to share the assessment criteria with students in advance can help students either to understand the learning expectations or to do self-monitoring and self-assessment (Maxwell, 2001).

Six rubrics, which were developed in this study to show to the panel of experts in the first round of Delphi studies, how benchmarks can be evaluated by using various assessment tasks: multiple-choice test, essay test, oral presentation, teacher observation, project/exhibition, and portfolios.

Table 2.12: A model rubric for assessing an essay.

<table>
<tr><td colspan="2"><u>Directions for Scoring:</u>

Scores for the answer depend on how well the essay meets the criteria listed below. The points for each criterion is as follows:

Beginning Developing Accomplished Exemplary
(1 - 2)+++++++(3 - 4) +++++++ (5 - 6) +++++++ (7 - 8)
“1 or 2” points if it is unclear as to whether or not the criterion is met.
“3 or 4” points if the criterion is partially met.
“5 or 6” points if the criterion is almost met.
“7 or 8” points if the criterion is clearly met.</td></tr>
<tr><td>Criteria</td><td>Score</td></tr>
<tr><td>Understanding:
8/7 -- Shows complete understanding of the topic and processes.
6/5 -- Shows substantial understanding of the topic, ideas, and processes.
4/3 -- Response shows some understanding of the topic.
2/1 -- Response shows a complete lack of understanding for the topic</td><td></td></tr>
<tr><td>Information:
7/8 -- Information was accurate, complete and included opinions.
5/6 -- Information was accurate, complete, and sometimes included opinions.
4/3 -- Information was sometimes clear and accurate and all task questions were answered.
2/1 -- Information was accurate (Karl, & Stevens, 2000).</td><td></td></tr>
<tr><td>Illustration:
7/8 -- Appropriate, well-placed illustrations were used to make essential points.
5/6 -- Appropriate illustrations were used to make essential points.
4/3 -- Illustrations were used to make points.
2/1 -- Illustrations were used (Karl, & Stevens, 2000).</td><td></td></tr>
</table>

Continued

Table 2.12. Continued.

Features: 8/7 -- The essay details both key and hidden features of the topic and explains how they serve several purposes. 6/5 -- The essay details the key features of the topic and explains the purposes they serve. 4/3 -- The essay neglects some features of the topic or the purposes they serve. 2/1 -- The essay does not detail the features of the topic or the purposes they serve (Goodrich, 1997).	
Critique: 8/7 -- The essay discusses the strengths and weaknesses of the topic, and suggests ways in which it can be improved. 6/5 -- The essay discusses the strengths and weaknesses of the topic. 4/3 -- The essay discusses either the strengths or weaknesses of the topic but not both. 2/1 -- The essay does not mention the strengths or the weaknesses of the topic (Goodrich, 1997).	
Connections: 8/7-- The essay makes appropriate connections between the purposes and features of the topic and many different kinds of phenomena. 6/5 -- The essay makes appropriate connections between the purposes and features of the topic and one or two phenomena. 4/3 -- The essay makes unclear or inappropriate connections between the topic and other phenomena. 2/1 -- The essay makes no connections between the topic and other things (Goodrich, 1997).	
Point Value / Points Earned / Status 39 - 48 / -------- / Advanced 29 - 38 / -------- / Proficient 19 - 28 / -------- / Non-Proficient 1 - 18 / -------- / Not Meeting Standard	Your Score:

Summary

The review of literature has provided much insight regarding identification of benchmarks and performance assessment of technological literacy. A summary of chapter 2 is presented below.

1. The background of this study is that technology teachers in Taiwan are confronting a new national curriculum, and they need an appropriate assessment tool to effectively integrate their instruction with assessment in the new curriculum, and shift away from assessment of factual knowledge and low-level, easily tested performances.

2. It is the purpose of the study to help teachers solve their instruction and assessment problem and upgrade their instruction by identifying the benchmarks of technological literacy and determining assessment tasks.

3. The course of technology education in Taiwan has been renamed “Natural Science and Living Technology” according to the new ROC 2000 National Curriculum. The new course was taught and shared between science teachers and technology teachers. The instruction time allotted for this course will be 2.5% to 7.5% of total instruction time, depending on the schools.

4. From the related literature, one hundred and five benchmarks of technological literacy were identified and classified into 15 categories in three domains of teaching content: “development of technology,” “thinking skills,” and “design and make.” The computer course was excluded. The benchmarks were identified according to whether they are aligned with curriculum goals, can be used for engaging in learning activities, and are suitable for performance assessment.

5. Although research about the assessment of technological literacy in Taiwan is insufficient, many relevant research studies about curriculum content, learning outcomes, competency of teachers and students, assessment tools, and research methods being used have been collected and summarized. The results reveal that both performance standards and performance assessment of technological literacy were not created in Taiwan. Most of the classroom assessments and competency evaluations in the field of technology education still rely on traditional paper-and-pencil tests. However, the Delphi techniques are widely applied in studying curriculum and competencies.

6. Six assessment tasks, multiple-choice test, essay test, oral presentation, teacher observation, project/exhibition, and portfolios, were identified for construction of the performance assessment. Furthermore, models of six rubrics for these six assessment tasks have been developed that focus on whole-school planning and student learning.

The literature review has provided us a starting point from which to postulate the benchmarks of technological literacy. In particular, the requirements for assessment and curriculum in Taiwan and theories and practices of performance assessment will help us to discover answers to the research questions.

CHAPTER 3

METHODOLOGY

This chapter delineates the design and methodology of the study. The discussion will include five main parts: research design, research methods, procedures, data collection, and data analysis. It was the purpose of this study to determine the benchmarks and assessment method to measure technological literacy as specified in the ROC 2000 National Curriculum Guidelines in Taiwan. A sequence of questionnaires, which focus on benchmarks and assessment methods, was used to elicit information from technological professional in Taiwan. Data were collected and analyzed to answer the following research questions:

Research Questions

1. What are the appropriate benchmarks to assess technological literacy in the area of "development of technology," a portion of the Natural Science and Living Technology curriculum as required by the ROC 2000 National Curriculum Guidelines in Taiwan?
2. What are the appropriate benchmarks to assess technological literacy in the area of "design and make," a portion of the Natural Science and

Living Technology curriculum as required by the ROC 2000 National Curriculum Guidelines in Taiwan?

3. What are the appropriate benchmarks to assess technological literacy in the area of "thinking skills," a portion of the Natural Science and Living Technology curriculum as required by the ROC 2000 National Curriculum Guidelines in Taiwan?

4. What are the appropriate assessment tasks to assess technological literacy in the Natural Science and Living Technology curriculum as required by the ROC 2000 National Curriculum Guidelines in Taiwan?

Research Design

A three-round Delphi process with interviews and data analysis was used to develop a consensus among 24 experts in Taiwan on the benchmarks and assessment method for "Living Technology" as specified in the ROC 2000 National Curriculum Guidelines.

In the first stage, all prevailing benchmarks of technological literacy for junior high school students were explored and analyzed through a review of the literature, and ultimately became the framework for the first questionnaire for data collection. A panel of 24 experts was selected from superlative technology teacher educators, technology teachers, and administrators in Taiwan. Within the three-round Delphi processes, they were asked to offer their professional judgment and ideas on following propositions:

1. Appropriate benchmarks of technological literacy for ninth grade junior high school students,

2. Appropriate assessment methods, types of tests or tasks, which can be used to measure technological literacy.

During each round of the Delphi process, the responses from the experts were statistically processed, summarized, and used to construct another more focused questionnaire to be sent to the experts again. The process of sending, receiving, revising, and sending again in each round of the Delphi process were continued until the ideas were clarified, a consensus was reached, or no new information was gained, or until the third round.

Both the interviews and the Delphi technique used in the study gathered qualitative information by asking open-ended and exploratory questions; therefore, they were classified as qualitative research methods (Myers, 1997).

In fact, the Delphi techniques are classified as both qualitative research methods (NPRES, 2001) and inductive methods (McClure & Herndon, 1991). Consequently, the research methods being used in this study can be classified as qualitative and inductive in nature.

<u>Research methods</u>

The research planning, approaches, and rationales utilized in this study, including choice of the research method and selection of the panel of experts, were discussed in the following sections.

Methods chosen

The research methods used in this study included analysis of existing data, interviews, Likert scale to elicit judgments on the importance of benchmarks, and the Delphi technique to obtain consensus from experts. The identification of benchmarks and assessment tasks for assessing technological literacy were classified as social and cultural phenomena and are qualitative in character. These research tasks were best explored through qualitative methods. Among all qualitative methods the Delphi technique was chosen as the main research method. The reasons for choosing the Delphi technique in this study have been discussed in chapter 2.

Analysis of existing data

The content and benchmarks to be used in assessing technological literacy of junior high students as required by the ROC 2000 National Curriculum Guidelines in Taiwan were identified by a review of literature and analysis of existing data. Data sources for this research method included books, periodicals, electronic databases, and web pages. Words like "technological literacy/competence," "performance indicators," "performance assessment," "benchmarks," "standards," and other relevant keywords were used as codes in the inspection of all documents. Concepts and benchmarks of technological literacy were compared, organized, and, as a result, compiled into a set of 150 benchmarks in 15 categories, and six assessment tasks illustrated with rubrics.

The compiled list of benchmarks and assessment tasks was sent to technology professionals and administrators in Taiwan for comment and suggestion in the Delphi probe stage. Interview, phone call, e-mail inquiry, and follow-up letters were used to collect data. Based on the findings of the Delphi probe, a list of 105 benchmarks and 5 assessment tasks were identified and became the framework of the questionnaire to be used in the first round of the Delphi survey.

Interviews

The semi-structured individual interviews took place in Taipei, Taiwan from July to September of 2001. The interviews were focused on the assessment of technological literacy practices. Specifically, they were focused on the benchmarks, assessment tasks, and the influential stakeholder convictions in regard to the assessment of technological literacy.

Twenty-four individual interviews were held. The interviewees included 12 technology teachers from junior high schools and senior high schools and 12 technology teacher educators from universities in Taiwan. Elementary school teachers were excluded from the interview process because the study is focused on the junior high school level. Senior high school teachers were included because most junior high school graduates will go to senior high schools, and, moreover, almost all senior high school teachers are promoted from junior high schools in Taiwan, and their expertise is valuable to this study.

To identify the appropriate benchmarks and appropriate assessment method, semi-structured face-to-face interviews and telephone interviews were used. A data-collection instrument for the interview (see Appendix D), includes a list of systematically organized, relevant, and easy to answer questions, was prepared before the interviews, although it was not anticipated that it would be followed precisely. To get the most data from an interview, it is necessary to ask questions flexibly to accommodate the unique character and mood of an interviewee. Also open-ended questions were asked to elicit different perspectives.

A face-to-face interview permits more complex questions and enables the interviewer to establish rapport with the respondent, while a telephone interview is less costly and takes less time than a personal interview (ERIC/AE, 1997). To interact with experts in remote areas, telephone interviews were used to supplement face-to-face interviews. The purpose was to involve as many qualified technology teacher educators and technology teachers in Taiwan as possible. Because e-mails were used in the Delphi process, personal contacts of possible participants by researcher were made first.

In Taiwanese culture, it is necessary to have personal contact, which can best be established through a mutual friend and a commitment of friendship, in order to get sincere help in either e-mail or mail replies from participants who do not personally know the investigator. In judging effectiveness from the viewpoint of "relationship", the cover letter of the questionnaire has been of little value or even meaningless to persuade participants to respond to the questionnaire.

Revised magnitude estimation scaling

The panel of experts was asked to comment on the related importance of the benchmarks in the first round of the Delphi process. To obtain more precise and reliable data, a “Magnitude Estimation Scaling” (MES) method (Sturges, 1990) was revised for data collection in this study to adapt it to the conventions of respondents in Taiwan.

The revised magnitude estimation scaling has the advantage of being a "ratio" scale, which is superior to an ordinal scale (Gay, 1996) such as the traditional Likert type scaling. The revised magnitude estimation scaling is an anchored scale -- it contains a reference point by which to compare perceptions. It has been revised to restrict the ratio of comparison from 0 to 2.0, because the anchor is set at 50; in other words, the range of answers was restricted from 0 to 100.

Although the revised scaling may not be successful in representing the respondents' ideas when they feel certain items are more than three times as important than the anchored item, it fits the scaling convention of teachers in Taiwan. That is because people in Taiwan are trained since primary schools to represent a value by offering a score from 0 to 100. When using the MES method, they can assign a score corresponding to a value judgment subconsciously without actually doing the multiplication as suggested.

To make it easier for participants using the revised magnitude estimation scaling, the 150 benchmarks were grouped into 15 clusters with seven benchmarks in each cluster. This is based on the assumption that it was easier for respondents to make comparisons on 10 or less items (Altschult, 2000).

Based on the findings of a field test in May 2002 and a Delphi probe in July 2002, most of the respondents did not enjoy the MES method. After reconsideration, a four-point Likert scale was applied instead. That is because there is no strong evidence from literature to support the validity of the revised magnitude estimation scaling.

The four-point rating scale allowed respondents to evaluate the importance of benchmarks. With an even number of points on the scale, respondents rated a benchmark as either important (3 or 4) or of non-important (1 or 2). The reason to employ a four-point rating scale instead of a five-point rating scale is that a questionnaire without a "don't know" or "no opinion" category will decrease the number of unusable response (Black, 1995). The possibility of artificial opinion by forced-choice item (Klajman, 1995) is minor, because those questions in the questionnaire would not be difficult to understand by the panel of experts.

Delphi Technique

As discussed in chapter 2, a three-round Delphi process was to be used in this study because of its advantages: anonymity, cost-effectiveness, time saving, the benefit of subjective judgments (Linstone & Turoff, 1975), group communication and its value for identifying performance problems and assessing needs (Lang, 1998).

In the beginning, an e-mail application of the Delphi process was planned for the study because it can save time and mailing and handling expense compared with the traditional mailing approach (Synder-Halpern et al., 2000). Incentives such as refreshments, small gifts, and having tea together to build up relationships were used to promote the response rate of the Delphi study. But, after the Delphi probe stage in July 2002, it was concluded that e-mail inquiry should be replaced with mailing because of the low return rate.

Panelists composed of 24 technology educators and practitioners from different levels of educational institutes, were queried in the three-round of Delphi study. In the first round of the Delphi process, the panelists evaluated and justified the proposed 105 benchmarks of technological literacy. They added new benchmarks and gave comments. Panelists were also examined and determined the appropriate assessment tasks and classification of technological literacy.

The consensus is assumed to have been reached when a two-thirds majority of participants agree with a particular viewpoint. For the purpose of this study, the consensus of an item was considered to have been reached when its standard deviation is lower than 0.8, which means 70% participants agree, i.e. 17 out of 24 panelists agree.

In each round of the Delphi method, the responses from the panelists were statistically processed and the results were returned to all respondents. After examining the mean and standard deviation of the group response, panelists can request to revise their predictions or to support their positions. After panelists gave their further opinions, they received feedback of the result after further statistical processing. Altogether, in the three rounds of the Delphi processing, panelists received questionnaires and results three times, until a predetermined level of consensus (e.g., by examining the statistics of central tendency and variability) was reached.

Precautions in processing the Delphi technique include: maintain strict anonymity of the participants (Lang, 1998); encourage participants to comment on their rationale for the rating and to add additional items (Ludwig, 1997); explore areas of disagreement; avoiding inserting moderator opinions into panel feedback; planning enough turnaround time between rounds; and avoiding over-generalization of results (Synder-Halpern et al., 2000)

Selection of experts

Expertise is the key requirement in selecting the panel of experts for the Delphi technique. Factors in determining expertise include educational level, work experience, publications, socioeconomic status, and reputation in the profession of technology education. Twenty-four experts were invited to participate in the panel because both Ludwig (1997) and Ziglio (1996) affirm that a panel size of 15-20 should be large enough.

Although the recommendation of experts were solicited from highly-regarded teacher educators, principals, and administrators; specific guidelines were developed to guide the nomination criteria for the recruitment of technology teacher educators, technology teachers, and administrators:

1). Because the Industrial Technology Education Association in Taiwan (ITEAIT) is a well-known professional organization of technology education in Taiwan, it was required for the participant of this study to currently be a member of ITEAIT, or to have been a member within the last three years.

2). In regard to the educational level, the nominee had to hold a Master’s degree or higher.

3). The nominee had to have at least three years experience for teaching technology education.

4). The nominee had to have published articles in the field of technology education -- more than two papers if he/she were a technology teacher or more than 10 papers if he/she were a technology teacher educator.

5). The nominee had to have working experience on the revision of National Curriculum Guidelines in the field of technology education.

6). The nominee had to have endeavored to improve the quality of technology education, knowledge and experience to base their future activities upon, be knowledgeable about technological literacy, be self-motivated, and agree to participate in this study.

Classification of Panel of Experts	Numbers	Criteria
Junior high technology teachers	10	Published more than 2 papers Teaching: more than 5 years Masters degree or higher Member of ITEAIT,
Senior high technology teachers	6	Published more than 4 papers Teaching: more than 3 years Master degree or higher Member of ITEAIT,
Technology teacher educators	6	Published more than 8 papers Teaching: more than 3 years Doctoral degree Member of ITEAIT,
Administrators	2	Published more than 2 papers Teaching: more than 3 years Masters degree or higher Member of ITEAIT,

Table 3.1: The classification, numbers, and criteria for panels of experts.

In conclusion, the main criteria for selecting experts were teaching experience and research credentials in the area of technology education. Furthermore, all of the experts were expected to be acquainted with technological literacy. The classification, numbers, and criteria for the three panels are shown in Table 3.1.

As shown in Table 3.1, 10 junior high school technology education teachers, six senior high school technology education teachers, six technology teacher educators from university technology programs, one executive officer from the Department of Elementary and Junior High School Education in Taiwan, and two deans of instruction of junior high schools, who had master degree of technology education, were selected as the panel of experts in this study.

To locate qualified expert who are among the best technology teachers in Taiwan, inquiry was made of one association-ITEAIT and two technology teacher-training programs in Taiwan (the National Taiwan Normal University and the National Kao-Hsiung Normal University). The list of candidates was compiled and includes senior members of ITEAIT and distinguished teachers nominated by the university faculty. Dr. Lung-Sheng Stephen Lee, Dean of Technology of NTNU, and Dr. Shi-Tow Ted Tsai, leader of the Research Committee at the Department of Industrial Technology Education of NTNU, offered assistance in locating candidates.

Moreover, they worked collaboratively with four other technology teacher educators -- Dr. Kuo-hung Tseng and Dr. Chung-Shan Sun, former and current department heads of industrial technology education of the National Kao-Hsiung Normal University; Dr. Chien Yu and Dr. Chung-Hsiung Fang, former and current department heads of industrial technology education of the National Taiwan Normal University. Together they established a “Tech Ed in Taiwan” counseling committee (see Appendix B) and had offered their counsel to the researcher on doing the inquiry in Taiwan. They assess the content of the questionnaires based on their expertise in the content and subject matter of technology education, assessment of Taiwanese students, and bilingual competency. The Chinese interpretation of the questionnaires was revised by incorporating their recommendations before sending them to the panel of experts.

All candidates were contacted either by telephone or e-mail to determine their qualifications and willingness to participate. Based on the inquiries, a tentative list of experts for Delphi study was generated.

After the proposal was approved by the dissertation committee, an invitation with a brief description and schedule of the inquiry process was sent to all of the experts, along with a request for their formal commitment to participate in the study. It is shown that, from the process of the study, every member of the panel of experts shared his/her perspectives and professional judgement to help in developing the important benchmarks and appropriate assessment method for assessing studen technological literacy, as required by the ROC 2000 National Curriculum Guidelines in Taiwan.

Procedures

To ensure success, research procedures should be well planned beforehand and rationale for using each approach to data collection should be clear. Overall, the procedures of this study can be divided into the preparation stage and the Delphi study stage.

Three tasks were included in the preparation stage: to involve possible experts; to identify potential benchmarks for technological literacy; and to design assessment tasks for measuring technological literacy. Design and problem-solving processes were taken in these three tasks to ensure a satisfactory preparation for the Delphi process. The discussion of procedures is divided into four parts: schedules for each research process; the interview and involvement of experts; preparation for the Delphi survey (instrument design and development); and management of the Delphi process.

Date	Tasks	Descriptions
9/12/1998 -- 6/30/2001	Studies	Review of literature Identify problem Research method design
7/1/01 -- 9/30/01	Selection panels	Informal investigation, Interviews Setting criteria, correspondence Identify panel of experts
8/1/01 -- 4/30/02	Design	Identify and classify proposed benchmarks Design proposed assessment tasks Design data collection instruments
5/1/02 -- 6/30/02	Orientation and Preparation	Complete human subjects review process Correspondence and incentive Explanation on implementation of the study
7/1/02 -- 6/30/03	Delphi studies and Documentation	Identifying benchmarks and assessment tasks Data analysis Data documentation

Table 3.2: Research Timeline.

The research processes

As can be seen in Table 3.2, the structure of the research and the progression of study activities were established as follows:

1. To conduct a review of literature, and to plan the research methods.
2. To query technology teachers and educators about their assessment and grading practices, especially related to the assessment of technological literacy.

3. To set criteria and select qualified experts for the panel.
4. To prepare all questions for questionnaires (e.g., benchmarks, assessment tasks) and strategies for inquires.
5. To prepare incentives and corresponded with panel of experts to explain the study's process, and to complete the human subjects review process;
6. To conduct a three-round Delphi survey.
7. To complete the data analysis, discussion, and documentation.

Interviews and recognition of experts

Interviews were performed before, during, and after the development of instruments. Findings from the interviews contributed to the development of a realistic questionnaire. In the initial stage, the process depended upon the literature review; interviews were also used to investigate the expert opinions on performance assessment and technological literacy. At the stage of instrument development, the experts approved the initial questionnaire and then six technology teachers in Taiwan made a final revision based on the result of a field test.

At the stage of locating and identifying the panel of experts, the interview method was employed again to investigate the expertise of candidates for the panel. Interviews in person and by e-mail or phone call were conducted to verify the candidates' professional qualities and acceptability for the study. Additionally, cover letters and incentives were utilized in seeking consent to participate in this study. The decision of selecting the panelists was finalized after the Delphi probe.

Instrument design and development

To prepare for the Delphi survey, an initial "Delphi probe" was accomplished. The Delphi probe consists of a comprehensive, broad-based listing of benchmarks and open-ended inquiry to develop an initial list of benchmarks. Besides, a variety of assessment tasks such as observation, oral presentation, essay, portfolio, projects, and peer-evaluation were also included in the open-ended questionnaire for identifying the appropriate assessment tasks.

The tentative list of 150 benchmarks was developed by the researcher, based on the Standards of Technological Literacy (ITEA, 2000) and the Learning Standards for MST (NYSED, 1996). These tentative benchmarks were organized into fifteen categories of technological literacy:

[1] The characteristics and scope of technology
[2] The core concepts of technology
[3] Tools, resources, systems, technological processes, and relationships
[4] Technology, society and human living (social, ethical and human issues)
[5] Impacts and influence of technology
[6] History and evolution of technology
[7] Agricultural, medical, and biotechnologies
[8] Energy and power, transportation technologies
[9] Computer and information technologies
[10] Manufacturing and construction technologies
[11] Applying the design process and engineering design
[12] Innovation, problem solving, troubleshooting, R&D, and experimentation
[13] To maintain systems and products
[14] Accessing, using, and managing the technology
[15] Problem solving, creative, critical, systems and reasoning thinking

Ten benchmarks for each of the above 15 categories were organized to develop the questionnaire for the Delphi probe. Respondents were asked to select three of the most irrelevant or non-important benchmarks out the 10 benchmarks within each category, or to add any benchmark they felt were missing.

In June 2002, the questionnaire was sent to 40 possible panel members and 720 administrators in Taiwan through e-mail. The 720 administrators, who were principals or deans of instruction of junior high schools, were asked to forward the list to their technology teachers and to encourage their teachers to review the benchmarks on the list. In July 2002, a follow-up letter (Appendix G) providing with a stamped, pre-addressed envelope was mailed to try to help increase the return rate. Two weeks after mailing the letter, a telephone call was placed to each of the possible panel members to serve as a reminder. All responses were carefully examined for clarity and accuracy by the researcher. Those benchmarks that conveyed parallel concepts were combined. Finally, a questionnaire consisting a list of 105 benchmarks and five assessment methods was developed for the first round of the Delphi process.

Responses from the panelists in the first round of the Delphi study were used to construct a second-round instrument. Means, standard deviations, and data distribution were computed for each benchmark by using EXCEL statistical software to determine whether consensus was obtained. All benchmarks with a standard deviation equal to or less than 0.780, were assumed to have reached consensus by the panel. Among them, benchmarks with a mean rating either higher than 3.290 or lower than 2.834 were removed from the original 105 benchmarks and did not appear in the second round. Similarly, those benchmarks without consensus and those benchmarks with consensus but which failed to be identified as either important or non-important in the second-round questionnaire were kept in the third-round questionnaire.

In the questionnaire to be used in the second and third round of the Delphi process, the benchmarks were listed with the mean ratings of the panel, individual's prior ratings, and space for new ratings. Panel members were asked to reconsider their previous answers and adjusted them if they wanted.

These initial questionnaire designs were submitted for critique. The researcher's dissertation advisor as well as the "technology education in Taiwan" counseling committee members compared the questionnaires to the purpose of the study and the research questions and attested to the content-validity of the questionnaires.

Thus, four questionnaires were designed for a Delphi inquiry to: establish potential benchmarks of technological literacy – Delphi Probe Instrument (see Appendix G), determine appropriate benchmarks and assessment tasks - Round I Instrument (see Appendix H), determine appropriate benchmarks and assessment tasks - Round II Instrument (see Appendix I), and determine appropriate benchmarks and assessment tasks - Round III Instrument (see Appendix J).

Before the final revisions, these four questionnaires were sent for pilot testing to six technology teacher educators and six technology teachers in Taiwan. The objective of this pilot was to determine possible communication problems in the questionnaires. Feedback from those 12 participants and the results of the pilot test were used as a basis to complete the final revision of these four questionnaires.

Managing the Delphi processes

Within the three-round Delphi process, questionnaires were mailed to the 24 experts/participants of the study. Questionnaire results from the entire panel were fed back to the participants and they were given the chance to reconsider and, if necessary, restate their opinions or present new ideas. When consensus is reached or no new ideas are presented, the final results were analyzed, reported, and used to create a new instrument for the next round of the Delphi process.

The cover letter described the purpose of the round and provided questionnaire response directions. The questionnaire, which includes 105 benchmarks statements accompanied with a four-point Likert scale, asked experts to rate the importance of each benchmark. Experts were also asked to add new benchmarks to the list in the questionnaire and rated their importance. The result of the statistical processing of these ratings was used as feedback to the panel of experts. They reviewed the rank order for each benchmark and made recommendations for movement in the rank order. Their recommendations were statistically processed and fed back to all respondents again to give further opinions about the results of the statistical processing.

After the three rounds were completed, a final summary report was mailed to all panel members. When developing the questionnaires and processing the responses, precautions such as "avoid inserting moderator opinions into panel feedback" and "explore areas of disagreement" were taken to eliminate the chance of research bias.

Data collection

Data collection process: identifying the benchmarks

In the Delphi study, the 105 proposed benchmarks divided into three categories accompanied by a Likert scale were examined, evaluated, added, deleted, and ranked by panel members. The responses were grouped and collated to reduce the number of benchmarks to a manageable size. The recommendations were statistically processed and fed back to all respondents. This process was repeated until consensus was reached on the important benchmarks.

In the first round of the Delphi process, all benchmarks, which the participants rated above the mean score of 3.290 on a 4.0 scale, were considered essential. In second round, those benchmarks with a mean score higher than 3.000 were considered important. In the third round, benchmarks with a mean score higher than 2.875 were considered important. After the three round Delphi process, the most important benchmarks viewed by the panelists were finally identified.

The data collection process: identifying the assessment tasks

The six proposed assessment tasks for measuring technological literacy, including teacher's observation, essays test, oral presentation, project/exhibition, portfolios, and design or problem solving logs were sent to experts for examination and evaluation.

In the stage of Delphi probe, participants provided many ideas about the tests, tasks, scoring of each task, and content areas should be covered in each task. Their responses were statistically processed as shown in Table 3.3.

Assessment tasks	Percentage of scoring	Benchmarks being tested (The number of benchmarks)
Multiple choice test	30%,	1,3, 4-9, 17, 28, 30-58
Essay test	10%,	11-16, 18-27, 38-55,
Oral presentation	15%	2, 29, 56-60,
Projects/exhibitions	16%,	10, 25-37,
Portfolios	21%	23, 50-60.
Design or problem solving logs	8%	1, 9, 13,

Table 3.3: An example of assessment tasks design.

Among all assessment tasks, the assessment task -- design and problem solving logs, was not being common accepted, and was eliminated from the questionnaire for the first round of Delphi study. To assure that all participants having the same perspective on each assessment task, brief description and rubrics of each assessment tasks were sent with questionnaire (Appendix H).

Data collection process: ethical considerations

To differentiate between "What can be done" and "what should not be done" in the process of data collection, so that an unethical behavior can be prevented is the obligations of every researcher. Moral and ethical considerations in the data collection process include:

1. Always present the questions and results honestly, clearly, and ethically;
2. Before sending out a questionnaire, examine the ethical, legal, and social implications and human issues surrounding the question;
3. Practice ethical and responsible use of technology systems, information, and

software during data collection (Jahn, 2001);

4. Give consideration to how to regulate the procedures of testing and the uses of test results.

These ethical considerations guided the data collection process, promoted the quality of the research, raised cultural and ethical standards, and enriched national livelihood.

Data collection process: validity and credibility

Although validity, reliability, and generalization are terms applied to quantitative research, and not suitable for inspecting qualitative research (Spickett, 2002), yet validity is still more expressive than credibility to the general public. The validity of the Delphi process in this study were discussed as follows:

1. Because the expertise of participants contributes to the validity of the Delphi technique, strict nomination criteria and recommendation from authorities responsible for technology education and technology teacher educators and personnel in Taiwan are employed.
2. Precautions were taken to reduce the dropout rate of panel members. On the other hand, a variety of incentives were used to encourage a high response rate in the Delphi survey.
3. Phone calls and e-mail were used between the rounds of the Delphi survey to interact with panel members for the purposes of further clarification and building closer relationships or collaboration.

4. A counseling committee of technology education in Taiwan criticized each questionnaire and provided feedback in the study for the purpose of reducing bias that might occur.
5. During the Delphi studies, the gaining of consensus is to be examined by use of statistical methods such as frequency distribution and standard deviation.

Data analysis

Processing and analysis of the data were undertaken as follows:

1. After the questionnaires were returned, the responses were analyzed and summarized. A four-point Likert scale was used to gather the scores of importance of benchmarks.
2. Upon receipt of the returned questionnaires, the responses were summarized and analyzed. The results of data analysis were placed in a table displaying the perspectives of all experts about the importance of every benchmark.
3. Descriptive statistical methods were used in data analysis. These methods include frequency distribution, mean, mode, median, quartiles, quartile deviation, and standard deviation. Software such as the SAS (Statistical Analysis System) or EXCEL was employed.
4. The mean and standard deviation of each benchmark item were listed in rank order according to the magnitude of the mean of their response scores and the result given as feedback to experts. The same process was followed until consensus was reached.

5. After consensus was achieved, the results of study including summary, recommendations, comments, and the mean score and standard deviation were attached with the new questionnaire and sent to participants.

In summary, the above detailed description and discussion of the research design, methods, procedures, data collection and analysis supports the study. Implications and further research were considered. This study not only identified the benchmarks of technological literacy of ninth graders in Taiwan, but also determined the appropriate assessment tasks for assessing the students' technological literacy. Furthermore, through this study, knowledge about the assessment of technological literacy accumulated from experts was forged into a workable reference framework for improving the instruction and assessment of technology education in Taiwan.

CHAPTER 4

FINDINGS AND ANALYSIS OF THE DATA

Data results and analysis

A modified Delphi technique was used to collect and analyze the opinions of a panel of experts to achieve the purpose and to answer the research questions of this study. The participants in the study were technology professionals in Taiwan who had extensive experience as teachers, educators, and researchers (see Appendix A). This chapter will describe the procedures used and the results obtained from the analysis of the data between rounds and at the completion of the study.

An initial survey, Delphi probe, was used to elicit benchmarks, classifications of technological literacy, and assessment tasks for consideration in the three subsequent questionnaires used in Delphi process. The Delphi Probe questionnaire consisted of a prepared list of open-ended questions as well as rubrics to define the assessment tasks (see Appendix G). Responses provided by the panel members and the benchmarks appended by the researcher were collated and edited to be a questionnaire for the first round of the Delphi study (see Appendix H).

In round one of the Delphi study, the panelists were asked to rate the importance of 105 benchmarks using a four-point Likert scale. They were also asked to select appropriate assessment tasks for five categories of technological literacy. During this round, they could still add new benchmarks. Written responses to the open-ended questions in the first round were analyzed qualitatively.

In the second round, panel members were sent a list of 61benchmarks that had not reached consensus (having a standard deviation above .78), and were asked to rate the importance of each benchmark as well as reconsider their viewpoints about the assessment methods (see Appendix I). For the third and final round, participants were given a list of the 37 benchmarks that lacked consensus after the second round (see Appendix J).

It was determined that e-mail inquiry was not an effective means for the researcher to communicate with or collect data from the panelists. Due to the low response rate from e-mail, the express and certified mailing of the questionnaires by post was used. Furthermore, it was found that personal contact by phone from a department head or college dean to the panelists is advantageous in ensuring a high response rate.

Delphi probe

During this stage, those proposed benchmarks and assessment tasks were sent to 40 tentative panel members and 720 junior high schools in Taiwan by e-mail in June 2002. By the end of September 2002, 28 of the 40 possible panelists and 32 of the 720 administrators and technology teachers had responded. The low respond rate proves that e-mail is not a reliable inquiry method. However, the scattering of respondents comprises of principals, deans of instruction, and technology teachers around Taiwan, indicates that e-mail an efficient tool to publicize new ideas.

Based on the findings of the Delphi Probe, a preliminary framework of questions was built:

1. A list of 105 tentative benchmarks that mainly originated in the Standards of Technological Literacy (ITEA, 2000) was compiled.
2. A tentative categorization of technological literacy that included “development of technology,” “design and make,” and “thinking skills” was altered by the panel. Panelists were of the opinion that the category “development of technology” should be changed into “the understanding of technology;” the category “design and make” should be changed to include “design and build skills,” “application and problem-solving skills,” and “communication skills;” the category “thinking skills” should be changed to “inquiry and analytical skills.”
3. Therefore, the categories of technological literacy used in this study included the understanding of technology, design and build skills, application and problem solving skills, communication skills, and inquiry and analytical skills.
4. Most of the panelists concur with the thought that performance assessment should be emphasized rather than paper-and-pencil test. The appropriate assessment tasks for measuring technological literacy are teacher’s observations, oral presentations, essay Tests, projects, and portfolios.

Round I

As is the practice in a Delphi study, panelists remained anonymous throughout the study. As the study progressed, they obtain feedback in the next round questionnaire. Their ratings of each benchmark were statistically processed to get the mean score and standard deviation. Their written responses to an open-ended question in the first round were analyzed qualitatively.

Twenty-four experts participated in this study. They were asked to rate the importance of 105 benchmarks using a four-point Likert scale in which 1 = Very Unimportant, 2 = Below Average Importance, 3 = Above Average Importance, and 4 = Very Important. The panel members were also asked to select appropriate assessment tasks for measuring the five categories of technological literacy. They were given an opportunity to provide comment on benchmarks, assessment tasks, and classification of technological literacy.

Questionnaires from all 24 panelists were returned within 10 days. Those responses that commented on the benchmarks, classification of technological literacy, and assessment tasks were analyzed. Based on these suggestions one new benchmark was added, and three benchmarks and two categories of technological literacy were reworded.

Responses related to the assessment tasks of technological literacy are shown in Table 4.1. As viewed by panel members, oral presentations and essay tests were considered appropriate for assessing students' understanding of technology; using essay tests, projects, and portfolios to test inquiry and analytical technological skills was considered appropriate; communication skills could be assessed using teacher's observations, oral presentations, essay tests, and projects; design and build skills could be measured by using teacher's observations, projects, and portfolios; and application and problem solving skills could be examined using teacher's observations, projects, and portfolios.

	Teacher's observations	Oral presentations	Essay tests	Projects	Portfolios
Understanding of Technology	8	21	21	6	13
Design and Build Skills	22	2	3	19	16
Application and Problem Solving Skills	19	9	7	18	17
Communication Skills	16	17	18	14	11
Inquiry and Analytical Skills	10	13	20	17	20

Table 4.1: The assessment tasks for five categories of technological literacy viewed by the expert panel at the first round of Delphi studies, N= 24.

Table 4.2 shows the mean and standard deviation for each benchmark. The benchmark means ranged from a high of 3.792 (very important) to a low of 2.208 (very unimportant), and their standard deviation ranged from a high of .977 (great diversity of opinions) to a low of .481 (reached agreement).

The 35 highest mean rating benchmarks, with mean rating greater than 3.29, and standard deviation lower than .78, were considered most important with consensus reached. All the above benchmarks were excluded from the second round of inquiry. These benchmarks are 6, 7, 8, 10, 11, 12, 15, 19, 22, 23, 24, 31, 33, 35, 53, 56, 57, 59, 60, 61, 62, 64, 69, 73, 74, 85, 89, 90, 91, 92, 93, 94, 98, and 99.

The standard deviation cut-off point was set to .780 for the first round, because the distribution of data is symmetrical - the number of panelists who chose “very important” equals those who chose “very unimportant”, and the number of panelists who chose “above average importance” equals those who chose “below average importance.” The mean cut-off point was set to 3.290 for determining the important benchmarks because the distribution of data changes at that point and the number of panelists who chose “very unimportant” or “below average importance” becomes greater than those who chose “very important” or “above average importance.” The mean cut-off point was set to 2.830 for determining the non-important benchmarks in the first round because the distribution of data changes at that point and the number of panelists who chose “very unimportant” or “below average importance” started to rise radically from below three to greater than seven. The two benchmarks with high means for which consensus was not attained (Table 4.2) were benchmark number 30, “Understand that the use of inventions and innovations has led to changes,” with a standard deviation of .82, and number 51 “Knowing that energy can be grouped into major forms,” with a standard deviation of .81. The eight benchmarks having a mean rating lower than 2.55 were determined non-important and were excluded from the second round of inquiry. These benchmarks are 21, 44, 48, 49, 72, 79, 87, and 97.

In summary, through the first round of the Delphi study, 35 out of 105 benchmarks were determined to be important and 8 out of the 105 benchmarks were determined to be non-important. The remaining 61benchmarks were prepared for further inquiry in the second round. The results of Round I questionnaires are included in Table 4.2.

Table 4.2: The importance of benchmarks viewed by the expert panel, results of the first round Delphi. N= 24.

Scale: 1 = VU (Very Unimportant), 2 = BAI (Below Average importance), 3 = AAI (Above Average importance), 4 = VI (Very Important)
* Panelists reached consensus and viewed as important (MEAN > 3.290, SD < .780)
** Panelists reached consensus and viewed as non-important (MEAN < 2.830, SD < .780).

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
1	69	Be able to follow step-by-step directions to assemble or disassembly a product, observe, and discover how things work.	0	1	3	20	3.792*	0.509
2	92	Be able to use information provided in manuals, protocols, or by experienced people to see and understand how things work.	0	1	4	19	3.75*	0.532
3	33	Understand that humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.	0	0	8	16	3.667*	0.482
4	6	Criticize the use of technology affects humans in various ways, including their safety, comfort, choices, lifestyles, and attitudes about technology's development and use.	0	1	7	16	3.625*	0.576
5	59	Be able to use computers to access and organize information, or use it in various applications. Use technology to locate, evaluate, and collect information from a variety of sources. Use technology tools to process data and report results.	0	0	10	14	3.583*	0.504
6	56	Knowing what technologies are using to conserve the natural energy resources, and what approaches can be employed to use energy more efficiently in daily living.	0	1	8	15	3.583*	0.584
7	88	Identify, select, and use appropriate resources to solve problems.	0	1	8	15	3.583*	0.584
8	62	Use technology tools to enhance learning, increase productivity, and promote creativity.	0	2	6	16	3.583*	0.654

Continued

Table 4.2. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
9	90	Apply technological concepts and processes to solve practical problems and extend human capabilities.	1	1	5	17	3.583*	0.776
10	91	Demonstrate the ability to work safely, efficiently, cooperatively and independently.	1	1	5	17	3.583*	0.776
11	12	Knowing that people's needs and wants lead to the manufacturing of products, and when people's need and wants change, new technologies are developed.	0	1	9	14	3.542*	0.588
12	23	Understand that decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.	0	1	9	14	3.542*	0.588
13	98	Be able to select and safely use tools, products, and systems for specific tasks.	0	1	9	14	3.542*	0.588
14	61	Be able to communicate observation, processes, and results of the entire design processes, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.	0	2	7	15	3.542*	0.658
15	15	Knowing that resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.	0	0	12	12	3.5*	0.511
16	10	Understanding what in their world is natural and what is human made, and knowing that new technology is developed to solve problems and change the world around us.	0	2	8	14	3.5*	0.659
17	19	Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.	0	2	8	14	3.5*	0.659
18	31	Knowing that technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.	0	2	8	14	3.5*	0.659

Continued

Table 4.2. Continued

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
19	60	Use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.	0	2	8	14	3.5*	0.659
20	8	Understanding that technological systems include input, processes, output, and, at times, feedback; they work together to accomplish a goal.	0	3	6	15	3.5*	0.722
21	24	Understand that technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.	0	0	13	11	3.458*	0.509
22	94	Be able to recognize and use common symbols, such as graphic symbols, signals, and icons, to communicate key ideas.	0	2	9	13	3.458*	0.658
23	73	Knowing that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. To be able to express ideas to others verbally and through sketches and models, cause it is an important part of the design process.	0	3	7	14	3.458*	0.721
24	11	Be able to define technology encompassing past, present, and future developments and provides significant details and examples to illustrate the definition of technology.	0	0	14	10	3.417*	0.504
25	99	Be able to brainstorm people's needs and wants and pick some problems that can be solved by technology and through the design process.	0	2	10	12	3.417*	0.654
26	89	Understand that maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.	0	3	8	13	3.417*	0.717
27	64	Knowing that buildings generally contain a variety of subsystems, such as utilities systems, they are: water, electrical, plumbing, gas, waste disposal, heating and air conditioning, information and communication, as well as component systems, such as foundations, framing, insulation, and lighting.	0	2	11	11	3.375*	0.647

Continued

Table 4.2. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
28	35	Explains the interrelationships or connections between technologies and describe how technology has affected the environment and society.	1	1	10	12	3.375*	0.77
29	22	Understand that ethical considerations are important in the development, selection, and use of technologies. Describe personal consequences for the inappropriate or unethical use of technology.	0	3	10	11	3.333*	0.702
30	74	Knowing that the design processes include (1) defining a problem, (2), researching and generating ideas by brainstorming, (3) identifying criteria and specifying constraints, (4) exploring possibilities, (5) selecting an approach, (6) developing a design proposal, (7) making a model or prototype, (8) testing and evaluating the design using specifications, refining the design, (10) creating or making it, and (11) communicating processes and results.	0	3	10	11	3.333*	0.702
31	93	Knowing that technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.	0	3	10	11	3.333*	0.702
32	7	Illustrate how people generate new products and systems through creativity and innovation to meet their needs	0	1	15	8	3.292*	0.55
33	53	Knowing that power systems are used to drive and provide propulsion to other technological products and systems. Power systems must have a source of energy, a process, and loads.	0	3	11	10	3.292*	0.69
34	57	Knowing that the design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.	0	4	9	11	3.292*	0.751
35	85	Be able to use tools, materials, and machines safely to diagnose, adjust, and repair systems.	0	4	9	11	3.292*	0.751

Continued

Table 4.2. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
36	14	Knowing that the development and use of technology influence economic, political, social, cultural, and ethical issues .	0	2	14	8	3.25	0.608
37	28	Able to investigate and assess the influence of a specific technology on the individual, family, community, and environment.	0	2	14	8	3.25	0.608
38	32	Explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.	0	3	12	9	3.25	0.676
39	100	Knowing that asking questions and making observations helps a person to figure out how things work. Besides, Knowing that the process of experimentation, which is common in science, can also be used to solve technological problems.	0	4	10	10	3.25	0.737
40	102	Be able to test and evaluate the solutions for the design problem in relation to pre-established requirements, and then improve the design solutions or refine the design as needed.	0	4	10	10	3.25	0.737
41	4	Support that Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.	0	4	11	9	3.208	0.721
42	71	Understand that design goals and requirements must be established and constraints must be identified and prioritized during the time when designs are being developed. Knowing that the process of engineering design takes into account a number of factors (such as: safety, function, flexibility, quality, and economic, political, and cultural concerns).	0	5	9	10	3.208	0.779

Continued

Table 4.2. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
43	16	Able to explain how complex technological systems involve the confluence of numerous other systems. Explain how the submarine or airplanes involves communication, transportation, bio-technology, and manufacturing systems	0	3	14	7	3.167	0.637
44	42	Be able to identify trends and monitor potential consequences of technological development.	0	4	12	8	3.167	0.702
45	65	Knowing that manufacturing processes include designing products, gathering resources, and using tools to separate, form, combine materials in order to produce products, and servicing of products and systems. Servicing is included because it keeps products in good operating condition.	0	5	10	9	3.167	0.761
46	75	Knowing that a prototype is a working model used to test a design concept by making actual observations and necessary adjustments	0	5	10	9	3.167	0.761
47	13	Knowing that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.	0	4	13	7	3.125	0.68
48	66	Be able to design, fabricate models of construction, and work with other classmates in making a planned model community.	0	4	13	7	3.125	0.68
49	81	Explain and demonstrate several solutions to a problem or opportunity using technological design, tools, careful planning, experimentation, and testing.	0	3	16	5	3.083	0.584
50	103	Be able to compare, contrast, and classify collected information in order to identify patterns.	0	4	14	6	3.083	0.654
51	1	Justify the study of technology uses many of the same ideas and skills as other subjects; and the knowledge gained from other fields of study has a direct effect on the development of technological products and systems; Defend that technologies are often combined. Various relationships exist between technology and other fields of study.	0	6	10	8	3.083	0.776

Continued

Table 4.2. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
52	54	Knowing that transportation vehicles made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.	0	6	10	8	3.083	0.776
53	70	Able to explain how products are manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The cost associated with these functions may introduce yet more constrains on the design	1	3	13	7	3.083	0.776
54	80	Knowing that troubleshooting is a problem solving method used to identify the cause of a malfunction in a technological system.	0	5	13	6	3.042	0.69
55	45	Knowing that conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.	0	6	11	7	3.042	0.751
56	104	Be able to interpret and evaluate the accuracy of the information obtained and determine if it is useful. Be able to synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.	1	3	15	5	3	0.722
57	55	Knowing that transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.	0	6	13	5	2.958	0.69
58	68	Understand that: Structures are constructed using a variety of processes and procedures. Structures require maintenance, alternation, or renovation periodically to improve them or to alter their intended use.	1	4	15	4	2.917	0.717

Continued

Table 4.2. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
59	2	Appraise how corporations can often create a demand for a product by bringing it onto the market and advertising it; Support the idea that marketing involves informing the public about a product as well as establishing the product's identity, conducting research on its potential, advertising it, distributing it, and selling it.	0	7	14	3	2.833**	0.637
60	86	Be able to troubleshoot, analyze, and maintain system to ensure safe and proper function and precision.	0	7	15	2	2.792**	0.588
61	3	Interpret how creative thinking and economic and cultural influences shape technological development.	1	7	12	4	2.792**	0.779
62	37	Gather and organize information to create a database of historical events in technology development. Illustrate how technology has evolved throughout human history.	1	7	12	4	2.792**	0.779
63	9	Knowing that systems, which are building blocks of technology, are embedded within larger technological, social, and environmental systems. The stability of a technological system is influenced by all of the components in the system.	0	8	14	2	2.75**	0.608
64	77	Knowing that requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.	1	7	15	1	2.667**	0.637
65	76	Knowing that established design principles should be used to evaluate existing designs, to collect data, and to guide the design process. Be able to evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.	1	9	12	2	2.625**	0.711

Continued

Table 4.2. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
66	17	Knowing that an infrastructure is the basic framework of a system, which includes buildings, services, and installations needed for a government to function, such as transportation, communication, water, energy, and public information system.	1	10	10	3	2.625**	0.77
67	48	Knowing that biotechnology has application in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. Knowing that the sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures. Therefore, it is necessary to establish ethical mandates for regulating the incidence of testing and the uses of test results.	0	14	7	3	2.542**	0.721
All benchmarks above are having SD lower than .780 and are ranked by MEAN								
68	44	Knowing that agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products and in the care of animals.	2	10	10	2	2.500	0.780
69	63	Use a variety of media and formats to communicate information and ideas effectively to multiple audiences	0	5	8	11	3.250	0.794
70	101	Be able to explore the emerging technologies and develop the skills to evaluate their impacts by reasoning and making decisions based on asking critical questions.	1	8	11	4	2.750	0.794
71	84	Knowing that troubleshooting is a way of finding out why something does not work so that it can be fixed	1	6	12	5	2.875	0.797
72	51	Knowing that energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.	0	5	7	12	3.292	0.806

Continued

Table 4.2. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
73	18	Understand that access to and ability to use tools, materials, and skills limits technological development. Demonstrate the ways that multiple resources (such as people, information, tools and machines, techniques, materials, energy, capital, and time) are used to develop new technologies.	1	4	12	7	3.042	0.806
74	43	Knowing that medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. Medical technologies extend the effectiveness of medical care and increase people's wealth.	2	6	13	3	2.708	0.806
75	30	Describe the important technology inventions that have had significant impacts on human beings. Explain how technological inventions and innovations have caused global interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete.	1	2	9	12	3.333	0.816
76	79	Be able to use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. Design forecasting techniques to evaluate the results of altering natural systems.	4	9	10	1	2.333	0.816
77	25	Knowing that a number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.	1	11	8	4	2.625	0.824
78	52	Knowing that processes, such as receiving, holding, storing, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.	1	6	11	6	2.917	0.830

Continued

Table 4.2. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
79	72	Knowing that the design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.	2	10	9	3	2.542	0.833
80	27	Knowing that social and cultural priorities and values are reflected in technological devices. In other words, meeting societal expectations is the driving force behind the acceptance and use of products and systems. Understand that the management of waste produced by technological systems is an important societal issue	1	3	9	11	3.250	0.847
81	78	Explain how technological inventions and innovations stimulate economic competitiveness Explain through examples how some inventions are not translated into products and services with market place demand, and therefore do not become commercial successes. Describe the process that an inventor must follow to obtain a patent for an invention.	1	9	9	5	2.750	0.847
82	50	Knowing that power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.	1	7	10	6	2.875	0.850
83	82	Knowing that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	1	4	10	9	3.125	0.850
84	83	Describes and implements basic troubleshooting techniques for multimedia computer systems with related peripheral devices.	1	7	10	6	2.875	0.850
85	34	Explain that although technological effects are complex and difficult to predict accurately, humans can control the development and implementation of technology	2	7	11	4	2.708	0.859

Continued

Table 4.2. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
86	26	Understand that the transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.	2	8	10	4	2.667	0.868
87	47	Knowing that the development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.	1	8	9	6	2.833	0.868
88	5	Validate that technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.	1	5	9	9	3.083	0.881
89	36	Students will develop an understanding of the influence of technology on history.	2	4	12	6	2.917	0.881
90	40	Knowing that the specialization of function has been at the heart of many technological improvements.	2	10	8	4	2.583	0.881
91	41	Compare qualitatively and quantitatively the performance of a contemporary manufactured product, such as a household appliance, to the comparable device or system 50-100 years ago	1	7	9	7	2.917	0.881
92	95	Describe new management techniques incorporate some of these in a technological endeavor, and explain how they have reduced the length of design-to-manufacture cycles, resulted in more flexible factories, and improved quality and customer satisfaction.	3	7	11	3	2.583	0.881
93	97	Help to manage a group engaged in planning, designing, implementation, and evaluation of a project to gain understanding of the management dynamics.	4	8	10	2	2.417	0.881
94	49	Knowing that artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals	5	11	6	2	2.208	0.884

Continued

Table 4.2. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
95	29	Understand that with the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. The alignment of technological processes with natural processes maximized performance and reduces negative impacts on the environment.	1	9	8	6	2.792	0.884
96	58	Knowing that information and communication systems are made up of a source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. These systems can be used to inform, persuade, entertain, control, manage, and educate.	1	6	9	8	3.000	0.885
97	87	Demonstrate the ability to select, operate, maintain, troubleshoot, and dispose of technological devices in the context of a career (e.g., use the tools of accounting in a real or simulated business environment.)	3	9	9	3	2.500	0.885
98	21	Understand that an open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.	4	13	4	3	2.250	0.897
99	105	Knowing that systems thinking applies logic and creativity with appropriate compromises in complex real-life problems and involves considering how every part relates to others	2	9	8	5	2.667	0.917
100	96	Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget. Knowing that quality control is a planned process to ensure that a product, service, or system meets established criteria	4	5	12	3	2.583	0.929
101	38	Knowing that in the past, an invention or innovation was not usually developed with the knowledge of science. In fact, much science knowledge is being gathered alongside the technological development.	2	2	9	11	3.208	0.932

Continued

Table 4.2. Continued

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
102	46	Knowing that people in unsafe and remote areas can get medical care, such as being diagnosed or getting treatment with telemedicine. Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.	1	11	5	7	2.750	0.944
103	67	Knowing that the product design utilizes a broad range of manufacturing processes, such as metal forming, injection molding, rapid tooling, machining, abrasive water jet cutting, and finishing operations.	3	5	11	5	2.750	0.944
104	20	Understand that tools and machines extend human capabilities, such s holding, lifting, carrying, fastening, separating, and computing.	2	6	8	8	2.917	0.974
105	39	Knowing that making tools and processing new materials from natural materials advance the technology; besides, putting parts together to create systems and cooperating all specialized skill workers to solve sophisticate problems contribute to the modern technology.	2	8	7	7	2.792	0.977

<u>Round II</u>

Twenty-four experts participated in the second round of the Delphi study. They were asked to rate the importance of the 61benchmarks as well as to select appropriate assessment tasks for measuring the five categories of technological literacy.

Questionnaires from all 24 panelists were returned within 10 days. Responses related to the assessment tasks of technological literacy are shown in Table 4.3. As viewed by panel members, oral presentations and essay tests are considered appropriate for assessing students' understanding of technology; using essay tests, projects, and portfolios to test inquiry and analytical technological skills was considered appropriate; communication skills could be assessed using teacher's observations, oral presentations, and essay tests; design and build skills could be measured using teacher's observations, projects, and portfolios; and problem solving and application skills could be examined using teacher's observations, projects, and portfolios.

	Teacher's observations	Oral presentations	Essay tests	Projects	Portfolios
Understanding of Technology	4	21	24	4	10
Design and build Skills	23	2	1	24	16
Application and Problem Solving Skills	22	2	1	22	17
Communication Skills	14	20	20	11	6
Inquiry and Analytical Skills	5	9	23	13	21

Table 4.3: The assessment tasks for five categories of technological literacy viewed by the expert panel at the second round of the Delphi study, N= 24.

Table 4.4 shows the mean and standard deviation for each benchmark. The benchmark means ranged from a high of 3.375 (very important) to a low of 2.083 (very unimportant), and their standard deviation ranged from a high of .75 (great diversity of opinions) to a low of .38 (reached agreement).

The standard deviation cut-off point was set to .580 for the second round, because the distribution of data is symmetrical - the total number of panelists who chose “very important” or “above average importance” almost equals those who chose “very unimportant” or “below average importance.” The mean cut-off point was set to 3.000 for determining the important benchmarks, because the distribution of data changed at that point as the number of panelists who chose “very unimportant” or “below average importance” started to rise significantly from below three to greater than four. The mean cut-off point was set to 2.500 for determining the non-important benchmarks, because the distribution of data changed at that point as the number of panelists who chose “very unimportant” or “below average importance” started to rise drastically from below 10 to greater than half of the panelists.

The top 19 highest mean rating benchmarks, with mean rating greater than 3.0, and standard deviation lower than .65, were considered most important with consensus reached. These 19 benchmarks were excluded from the third round of inquiry. These benchmarks are: 1, 4, 5, 13, 14, 16, 27, 28, 30, 32, 38, 42, 51, 63, 65, 75, 100, 102, and 104. Twelve benchmarks had a mean rating lower than 2.58 and standard deviation lower than .72. They were determined non-important and were excluded from the third round of inquiry. These benchmarks are: 9, 40, 67, 76, 77, 78, 83, 86, 95, 96, 101, and 105.

Conclusively, after the second round of the Delphi study, 17 out of 61 benchmarks were determined to be important with agreement by the panelists, and 7 benchmarks were considered non-important. The remaining 31 benchmarks were prepared for further inquiry in the third round of the Delphi study.

Table 4.4: Result of the second round Delphi. N= 24. The importance of benchmarks viewed by the expert panel.
Scale: 1 = VU (Very Unimportant), 2 = BAI (Below Average importance), 3 = AAI (Above Average importance), 4 = VI (Very Important)
* Panelists reached consensus and viewed as importance (MEAN > 3.000, SD < .580)
** Panelists reached consensus and viewed as non-important (MEAN < 2.500, SD < .580).

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
1	28	Able to investigate and assess the influence of a specific technology on the individual, family, community, and environment.	0	0	16	8	3.333*	0.482
2	14	Knowing that the development and use of technology influence economic, political, social, cultural, and ethical issues.	0	0	17	7	3.292*	0.464
3	30	Describe the important technology inventions that have had significant impacts on human beings. Knowing that the use of inventions and innovations has led to changes in society and the creation of new needs and wants. Explain how technological inventions and innovations have caused global growth and interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete.	0	1	15	8	3.292*	0.550
4	38	Knowing that in the past, an invention or innovation was not usually developed with the knowledge of science. In fact, much science knowledge is being gathered alongside the technological development.	0	1	15	8	3.292*	0.550
5	51	Knowing that energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.	0	1	16	7	3.250*	0.532
6	4	Support that Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.	0	0	19	5	3.208*	0.415
7	42	Be able to identify trends and monitor potential consequences of technological development.	0	0	20	4	3.167*	0.381

Continued

Table 4.4. Continued

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
8	27	Knowing that social and cultural priorities and values are reflected in technological devices. In other words, meeting societal expectations is the driving force behind the acceptance and use of products and systems. Understand that the management of waste produced by technological systems is an important societal issue	0	2	16	6	3.167*	0.565
9	5	Validate that technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.	0	1	19	4	3.125*	0.448
10	13	Knowing that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.	0	1	19	4	3.125*	0.448
11	16	Able to explain how complex technological systems involve the confluence of numerous other systems. Explain how the submarine or airplanes involves communication, transportation, bio-technology, and manufacturing systems	0	2	17	5	3.125*	0.537
12	102	Be able to test and evaluate the solutions for the design problem in relation to pre-established requirements, and then improve the design solutions or refine the design as needed.	0	2	17	5	3.125*	0.537
13	100	Knowing that asking questions and making observations helps a person to figure out how things work. Besides, Knowing that the process of experimentation, which is common in science, can also be used to solve technological problems.	0	2	18	4	3.083*	0.504
14	1	Justify the study of technology uses many of the same ideas and skills as other subjects; and the knowledge gained from other fields of study has a direct effect on the development of technological products and systems; Defend that technologies are often combined. Various relationships exist between technology and other fields of study.	0	2	19	3	3.042*	0.464

Continued

Table 4.4. Continued

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
15	104	Be able to interpret and evaluate the accuracy of the information obtained and determine if it is useful. Be able to synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.	0	3	17	4	3.042*	0.550
16	54	Knowing that transportation vehicles made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.	0	3	18	3	3.000*	0.511
17	71	Understand that design goals and requirements must be established and constraints must be identified and prioritized during the time when designs are being developed. Knowing that the process of engineering design takes into account a number of factors (such as: safety, function, flexibility, quality, and economic, political, and cultural concerns).	0	3	18	3	3.000*	0.511
18	55	Knowing that transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.	0	3	19	2	2.958	0.464
19	70	Able to explain how products are manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The cost associated with these functions may introduce yet more constrains on the design	0	3	19	2	2.958	0.464
20	58	Knowing that information and communication systems are made up of a source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. These systems can be used to inform, persuade, entertain, control, manage, and educate.	0	4	17	3	2.958	0.550
21	82	Knowing that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	0	4	17	3	2.958	0.550

Continued

Table 4.4. Continued

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
22	66	Be able to design, fabricate models of construction, and work with other classmates in making a planned model community.	0	4	18	2	2.917	0.504
23	81	Explain and demonstrate several solutions to a problem or opportunity using technological design, tools, careful planning, experimentation, and testing.	0	4	19	1	2.875	0.448
24	45	Knowing that conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.	0	5	17	2	2.875	0.537
25	80	Knowing that troubleshooting is a problem solving method used to identify the cause of a malfunction in a technological system.	0	4	20	0	2.833	0.381
26	41	Compare qualitatively and quantitatively the performance of a contemporary manufactured product, such as a household appliance, to the comparable device or system 50-100 years ago	0	6	16	2	2.833	0.565
27	103	Be able to compare, contrast, and classify collected information in order to identify patterns.	0	6	16	2	2.833	0.565
28	25	Knowing that a number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.	0	6	17	1	2.792	0.509
29	68	Understand that: Structures are constructed using a variety of processes and procedures. Structures require maintenance, alternation, or renovation periodically to improve them or to alter their intended use.	0	7	17	0	2.708	0.464

Continued

Table 4.4. Continued

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
30	46	Knowing that people in unsafe and remote areas can get medical care, such as being diagnosed or getting treatment with telemedicine. Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.	0	8	15	1	2.708	0.550
31	52	Knowing that processes, such as receiving, holding, storing, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.	0	9	15	0	2.625	0.495
32	26	Understand that the transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.	0	10	13	1	2.625	0.576
33	40	Knowing that the specialization of function has been at the heart of many technological improvements.	0	13	11	0	2.458**	0.509
34	44	Knowing that agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products and in the care of animals.	0	14	10	0	2.417**	0.504
35	72	Knowing that the design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.	0	15	9	0	2.375**	0.495
36	101	Be able to explore the emerging technologies and develop the skills to evaluate their impacts by reasoning and making decisions based on asking critical questions.	0	16	7	1	2.375**	0.576

Continued

Table 4.4. Continued

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
37	96	Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget. Knowing that quality control is a planned process to ensure that a product, service, or system meets established criteria	0	17	6	1	2.333**	0.565
38	49	Knowing that artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals	1	19	3	1	2.167**	0.565
39	79	Be able to use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. Design forecasting techniques to evaluate the results of altering natural systems.	2	18	4	0	2.083**	0.504
All benchmarks above are having SD lower than .580 and are ranked by MEAN								
40	43	Knowing that medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. Medical technologies extend the effectiveness of medical care and increase people's wealth.	0	11	12	1	2.583	0.584
41	87	Demonstrate the ability to select, operate, maintain, troubleshoot, and dispose of technological devices in the context of a career (e.g., use the tools of accounting in a real or simulated business environment.)	2	15	7	0	2.208	0.588
42	50	Knowing that power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.	0	7	15	2	2.792	0.588
43	63	Use a variety of media and formats to communicate information and ideas effectively to multiple audiences	0	2	15	7	3.208	0.588

Continued

Table 4.4. Continued

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
44	67	Knowing that the product design utilizes a broad range of manufacturing processes, such as metal forming, injection molding, rapid tooling, machining, abrasive water jet cutting, and finishing operations.	0	14	9	1	2.458	0.588
45	78	Explain how technological inventions and innovations stimulate economic competitiveness and how, in order for an innovation to lead to commercial success, it must be translated into products and services with marketplace demand. Explain through examples how some inventions are not translated into products and services with market place demand, and therefore do not become commercial successes. Describe the process that an inventor must follow to obtain a patent for an invention.	0	13	10	1	2.500	0.590
46	21	Understand that an open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.	1	17	5	1	2.250	0.608
47	65	Knowing that manufacturing processes include designing products, gathering resources, and using tools to separate, form, combine materials in order to produce products, and servicing of products and systems. Servicing is included because it keeps products in good operating condition.	0	3	15	6	3.125	0.612
48	75	Knowing that a prototype is a working model used to test a design concept by making actual observations and necessary adjustments	0	3	15	6	3.125	0.612
49	47	Knowing that the development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.	0	9	13	2	2.708	0.624
50	97	Help to manage a group engaged in planning, designing, implementation, and evaluation of a project to gain understanding of the management dynamics.	2	17	4	1	2.167	0.637

Continued

Table 4.4. Continued

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
51	34	Explain that although technological effects are complex and difficult to predict accurately, humans can control the development and implementation of technology	0	10	12	2	2.667	0.637
52	95	Describe new management techniques (e.g., computer-aided engineering, computer-integrated manufacturing, total quality management, just-in-time manufacturing), incorporate some of these in a technological endeavor, and explain how they have reduced the length of design-to-manufacture cycles, resulted in more flexible factories, and improved quality and customer satisfaction.	0	18	4	2	2.333	0.637
53	32	Explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.	0	2	11	11	3.375	0.647
54	18	Understand that access to and ability to use tools, materials, and skills limits technological development. Demonstrate the ways that multiple resources (such as people, information, tools and machines, techniques, materials, energy, capital, and time) are used to develop new technologies.	0	6	14	4	2.917	0.654
55	84	Knowing that troubleshooting is a way of finding out why something does not work so that it can be fixed	2	6	16	0	2.583	0.654
56	36	Students will develop an understanding of the influence of technology on history.	1	6	15	2	2.750	0.676
57	39	Knowing that making tools and processing new materials from natural materials advance the technology; besides, putting parts together to create systems and cooperating all specialized skill workers to solve sophisticate problems contribute to the modern technology.	0	10	11	3	2.708	0.690

Continued

Table 4.4. Continued

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
58	29	Understand that with the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. The alignment of technological processes with natural processes maximized performance and reduces negative impacts on the environment.	0	9	11	4	2.792	0.721
59	83	Describes and implements basic troubleshooting techniques for multimedia computer systems with related peripheral devices.	2	9	12	1	2.500	0.722
60	105	Knowing that systems thinking applies logic and creativity with appropriate compromises in complex real-life problems and involves considering how every part relates to others	1	12	9	2	2.500	0.722
61	20	Understand that tools and machines extend human capabilities, such s holding, lifting, carrying, fastening, separating, and computing.	0	7	11	6	2.958	0.751

Round III

Twenty-four experts participated in the third round of the Delphi study. They were asked to rate the importance of 31 benchmarks as well as to select appropriate assessment tasks for measuring the five categories of technological literacy.

	Teacher's observations	Oral presentations	Essay tests	Projects	Portfolios
Understanding of Technology	3	24	23	2	12
Design and build Skills	24	0	0	24	13
Application and Problem Solving Skills	23	1	0	23	14
Communication Skills	13	24	21	10	2
Inquiry and Analytical Skills	0	6	24	14	24

Table 4.5: The assessment tasks for five categories of technological literacy viewed by the expert panel at the third round of Delphi study, N= 24.

Questionnaires from all 24 panelists were returned within 10 days. Responses related to the assessment tasks of technological literacy are shown in Table 4.5. As viewed by panel members, oral presentations and essay tests were considered appropriate for assessing students' understanding of technology; using essay tests, projects, and portfolios to test inquiry and analytical technological skills was considered appropriate; communication skills could be assessed using teacher's observations, oral presentations, and essay tests; design and build skills could be measured by using teacher's observations, projects, and portfolios; and problem solving and application skills could be examined using teacher's observations, projects, and portfolios.

Table 4.6 shows the mean and standard deviation for each benchmark. The benchmark means ranged from a high of 3.250 (important) to a low of 2.083 (non-important), and their standard deviation ranged from a high of .722 (great diversity of opinions) to a low of .408 (reached agreement).

The standard deviation cut-off point was set to .721 in the third round of the Delphi study, because the distribution of data is symmetrical - the total number of panelists who chose "very important" or "above average importance" almost equals to those who chose "very unimportant" or "below average importance." The mean cut-off point was set to 2.785 for determining the important benchmarks because the distribution of data changed at that point as the number of panelists who chose "very unimportant" or "below average importance" started to rise significantly from less than four to greater than six. The mean cut-off point was set to 2.540 for determining the non-important benchmarks. This was chosen because the distribution of data changed at that point and the number of panelists who chose "very unimportant" or "below average importance" became greater than the counterparts of the panel.

The top five highest mean rating benchmarks were 18, 54, 55, 70, and 82. They have a mean rating greater than 2.91 and standard deviation lower than .55, and are considered very important with consensus reached. The remaining 26 benchmarks were considered non-important. Altogether, after three rounds of the Delphi studies, 60 benchmarks achieved the panel's consensus and were determined to be important.

In summary, when the Delphi probe was completed, 105 benchmarks emerged as tentative benchmarks of technological literacy. After three Delphi rounds, 60 benchmarks were viewed as important and reached panel consensus. They were rated for their importance and also ranked according to their mean rating. These ranking are displayed in Table 4.7: In comparison, 26 benchmarks that were rated non-important and reached panel consensus are displayed in Table 4.8.

Table 4.6: Result of the third round Delphi. N= 24. The importance of benchmarks viewed by the expert panel.
Scale: 1 = VU (Very Unimportant), 2 = BAI (Below Average importance), 3 = AAI (Above Average importance), 4 = VI (Very Important)
* Panelists reached consensus and viewed as importance (MEAN > 2.875, SD < .721)
** Panelists reached consensus and viewed as non-important (MEAN < 2.540, SD < .721).

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
1	63	Use a variety of media and formats to communicate information and ideas effectively to multiple audiences	0	0	18	6	3.250*	0.442
2	32	Explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.	0	1	17	6	3.208*	0.509
3	75	Knowing that a prototype is a working model used to test a design concept by making actual observations and necessary adjustments	0	1	19	4	3.125*	0.448
4	65	Knowing that manufacturing processes include designing products, gathering resources, and using tools to separate, form, combine materials in order to produce products, and servicing of products and systems.	0	3	16	5	3.083*	0.584
5	18	Understand that access to and ability to use tools, materials, and skills limits technological development. Demonstrate the ways that multiple resources (such as people, information, tools and machines, techniques, materials, energy, capital, and time) are used to develop new technologies.	0	2	20	2	3.000*	0.417
6	82	Knowing that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	0	4	17	3	2.958*	0.550

Continued

Table 4.6. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
7	70	Able to explain how products are manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The cost associated with these functions may introduce yet more constrains on the design	0	3	20	1	2.917*	0.408
8	55	Knowing that transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.	0	4	18	2	2.917*	0.504
9	66	Be able to design, fabricate models of construction, and work with other classmates in making a planned model community.	0	6	15	3	2.875	0.612
10	20	Understand that tools and machines extend human capabilities, such s holding, lifting, carrying, fastening, separating, and computing.	0	6	16	2	2.833	0.565
11	58	Knowing that information and communication systems are made up of a source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. These systems can be used to inform, persuade, entertain, control, manage, and educate.	0	6	16	2	2.833	0.565
12	80	Knowing that troubleshooting is a problem solving method used to identify the cause of a malfunction in a technological system.	0	6	18	0	2.750	0.442
13	81	Explain and demonstrate several solutions to a problem or opportunity using technological design, tools, careful planning, experimentation, and testing.	0	7	17	0	2.708	0.464
14	103	Be able to compare, contrast, and classify collected information in order to identify patterns.	0	7	17	0	2.708	0.464

Continued

Table 4.6. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
15	47	Knowing that the development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.	0	8	15	1	2.708	0.550
16	45	Knowing that conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.	1	7	14	2	2.708	0.690
17	25	Knowing that a number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.	0	8	16	0	2.667	0.482
18	26	Understand that the transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.	0	9	14	1	2.667	0.565
19	36	Students will develop an understanding of the influence of technology on history.	0	10	12	2	2.667	0.637
20	39	Knowing that making tools and processing new materials from natural materials advance the technology;	0	10	12	2	2.667	0.637
21	34	Explain that although technological effects are complex and difficult to predict accurately, humans can control the development and implementation of technology	0	11	11	2	2.625	0.647
22	84	Knowing that troubleshooting is a way of finding out why something does not work so that it can be fixed	0	10	14	0	2.583	0.504
23	50	Knowing that power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done	0	11	12	1	2.583	0.584
24	52	Knowing that processes, such as receiving, holding, storing, moving, delivering, and using conventions are necessary for the transportation system to operate.	0	11	13	0	2.542	0.509

Continued

Table 4.6 Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
25	68	Understand that: Structures are constructed using a variety of processes and procedures. Structures require maintenance, alternation, or renovation periodically to improve them or to alter their intended use.	0	13	11	0	2.458**	0.509
26	83	Describes and implements basic troubleshooting techniques for multimedia computer systems with related peripheral devices.	0	14	10	0	2.417**	0.504
27	43	Knowing that medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained.	0	15	8	1	2.417**	0.584
28	105	Knowing that systems thinking applies logic and creativity with appropriate compromises in complex real-life problems and involves considering how every part relates to others	0	16	6	2	2.417**	0.654
29	78	Explain how technological inventions and innovations stimulate economic competitiveness and how to translate into products and services with demand.	0	16	7	1	2.375**	0.576
30	67	Knowing that the product design utilizes a broad range of manufacturing processes, such as metal forming, injection molding, rapid tooling, machining, abrasive water jet cutting, and finishing operations.	0	18	5	1	2.292**	0.550
31	95	Describe new management techniques and explain how they have reduced the length of design-to-manufacture cycles, resulted in more flexible factories, and improved quality and customer satisfaction.	1	18	3	2	2.250**	0.676
32	21	Understand that an open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.	1	19	4	0	2.125**	0.448

Continued

Table 4.6. Continued.

Rank	Number	Benchmarks	1-VU	2-BAI	3-AAI	4-VI	Mean	S.D.
33	87	Demonstrate the ability to select, operate, maintain, troubleshoot, and dispose of technological devices in the context of a career (e.g., use the tools of accounting in a real or simulated business environment.)	1	20	3	0	2.083**	0.408
34	97	Help to manage a group engaged in planning, designing, implementation, and evaluation of a project to gain understanding of the management dynamics.	1	20	3	0	2.083**	0.408
All benchmarks above are having SD lower than .721 and are ranked by MEAN								
35	29	Understand that with the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. The alignment of technological processes with natural processes maximized performance and reduces negative impacts on the environment.	1	6	14	3	2.792	0.721
36	46	Knowing that people in unsafe and remote areas can get medical care, such as being diagnosed or getting treatment with telemedicine. Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.	1	11	10	2	2.542	0.721
37	41	Compare qualitatively and quantitatively the performance of a contemporary manufactured product, such as a household appliance, to the comparable device or system 50-100 years ago	1	12	9	2	2.500	0.722

Table 4.7: Important benchmarks viewed by the expert panel, results of the Delphi studies. Rank ordered according to their mean rating. N= 24.

Rank	Mean	S.D.	Number	Benchmarks
1	3.792	0.509	69	Be able to follow step-by-step directions to assemble or disassembly a product, observe, and discover how things work.
2	3.750	0.532	92	Be able to use information provided in manuals, protocols, or by experienced people to see and understand how things work.
3	3.667	0.482	33	Understand that humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.
4	3.625	0.576	6	Criticize the use of technology affects humans in various ways, including their safety, comfort, choices, lifestyles, and attitudes about technology's development and use.
5	3.583	0.504	59	Be able to use computers to access and organize information, or use it in various applications. Use technology to locate, evaluate, and collect information from a variety of sources. Use technology tools to process data and report results.
6	3.583	0.584	56	Knowing what technologies are using to conserve the natural energy resources, and what approaches can be employed to use energy more efficiently in daily living.
7	3.583	0.584	88	Identify, select, and use appropriate resources to solve problems.
8	3.583	0.654	62	Use technology tools to enhance learning, increase productivity, and promote creativity.
9	3.583	0.776	90	Apply technological concepts and processes to solve practical problems and extend human capabilities.
10	3.583	0.776	91	Demonstrate the ability to work safely, efficiently, cooperatively and independently (ITEA, 2000).
11	3.542	0.588	12	Knowing that people's needs and wants lead to the manufacturing of products, and when people's need and wants change, new technologies are developed.
12	3.542	0.588	23	Understand that decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.
13	3.542	0.588	98	Be able to select and safely use tools, products, and systems for specific tasks.

Continued

Table 4.7. Continued.

Rank	Mean	S.D.	Number	Benchmarks
14	3.542	0.658	61	Be able to communicate observation, processes, and results of the entire design processes, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.
15	3.500	0.511	15	Knowing that resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.
16	3.500	0.659	10	Understanding what in their world is natural and what is human made, and knowing that new technology is developed to solve problems and change the world around us.
17	3.500	0.659	19	Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.
18	3.500	0.659	31	Knowing that technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.
19	3.500	0.659	60	Use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.
20	3.500	0.722	8	Understanding that technological systems include input, processes, output, and, at times, feedback; they work together to accomplish a goal.
21	3.458	0.509	24	Understand that technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.
22	3.458	0.658	94	Be able to recognize and use common symbols, such as graphic symbols, signals, and icons, to communicate key ideas.
23	3.458	0.721	73	Knowing that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. To be able to express ideas to others verbally and through sketches and models, cause it is an important part of the design process.
24	3.417	0.504	11	Be able to define technology encompassing past, present, and future developments and provides significant details and examples to illustrate the definition of technology.

Continued

Table 4.7. Continued.

Rank	Mean	S.D.	Number	Benchmarks
25	3.417	0.654	99	Be able to brainstorm people's needs and wants and pick some problems that can be solved by technology and through the design process.
26	3.417	0.717	89	Understand that maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.
27	3.375	0.647	64	Knowing that buildings generally contain a variety of subsystems, such as utilities systems, they are: water, electrical, plumbing, gas, waste disposal, heating and air conditioning, information and communication, as well as component systems, such as foundations, framing, insulation, and lighting.
28	3.375	0.770	35	Explains the interrelationships or connections between technologies and describe how technology has affected the environment and society.
29	3.333	0.702	22	Understand that ethical considerations are important in the development, selection, and use of technologies. Describe personal consequences for the inappropriate or unethical use of technology.
30	3.333	0.702	74	Knowing that the design processes include (1) defining a problem, (2), researching and generating ideas by brainstorming, (3) identifying criteria and specifying constraints, (4) exploring possibilities, (5) selecting an approach, (6) developing a design proposal, (7) making a model or prototype, (8) testing and evaluating the design using specifications, refining the design, (10) creating or making it, and (11) communicating processes and results.
31	3.333	0.702	93	Knowing that technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.
32	3.333	0.482	28	Able to investigate and assess the influence of a specific technology on the individual, family, community, and environment.
33	3.292	0.550	7	Illustrate how people generate new products and systems through creativity and innovation to meet their needs

Continued

Table 4.7. Continued

Rank	Mean	S.D.	Number	Benchmarks
34	3.292	0.690	53	Knowing that power systems are used to drive and provide propulsion to other technological products and systems. Power systems must have a source of energy, a process, and loads.
35	3.292	0.751	57	Knowing that the design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.
36	3.292	0.751	85	Be able to use tools, materials, and machines safely to diagnose, adjust, and repair systems.
37	3.292	0.464	14	Knowing that the development and use of technology influence economic, political, social, cultural, and ethical issues .
38	3.292	0.550	30	Describe the important technology inventions that have had significant impacts on human beings. Knowing that the use of inventions and innovations has led to changes in society and the creation of new needs and wants. Explain how technological inventions and innovations have caused global growth and interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete.
39	3.292	0.550	38	Knowing that in the past, an invention or innovation was not usually developed with the knowledge of science. In fact, much science knowledge is being gathered alongside the technological development.
40	3.250	0.532	51	Knowing that energy can be grouped into major forms: thermal, radiant, electrical, mechanical, etc.
41	3.250	0.442	63	Use a variety of media and formats to communicate information and ideas effectively to multiple audiences
42	3.208	0.415	4	Support that Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.
43	3.208	0.509	32	Explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.
44	3.167	0.381	42	Be able to identify trends and monitor potential consequences of technological development.

Continued

Table 4.7. Continued.

Rank	Mean	S.D.	Number	Benchmarks
45	3.167	0.565	27	Knowing that social and cultural priorities and values are reflected in technological devices. In other words, meeting societal expectations is the driving force behind the acceptance and use of products and systems. Understand that the management of waste produced by technological systems is an important societal issue
46	3.125	0.448	5	Validate that technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.
47	3.125	0.448	13	Knowing that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
48	3.125	0.537	16	Able to explain how complex technological systems involve the confluence of numerous other systems. Explain how the submarine or airplanes involves communication, transportation, bio-technology, and manufacturing systems
49	3.125	0.537	102	Be able to test and evaluate the solutions for the design problem in relation to pre-established requirements, and then improve the design solutions or refine the design as needed.
50	3.125	0.448	75	Knowing that a prototype is a working model used to test a design concept by making actual observations and necessary adjustments
51	3.083	0.504	100	Knowing that asking questions and making observations helps a person to figure out how things work. Besides, Knowing that the process of experimentation, which is common in science, can also be used to solve technological problems.
52	3.083	0.584	65	Knowing that manufacturing processes include designing products, gathering resources, and using tools to separate, form, combine materials in order to produce products, and servicing of products and systems. Servicing is included because it keeps products in good operating condition.
53	3.042	0.464	1	Justify the study of technology uses many of the same ideas and skills as other subjects; and the knowledge gained from other fields of study has a direct effect on the development of technological products and systems; Defend that technologies are often combined. Various relationships exist between technology and other fields of study.

Continued

Table 4.7. Continued.

Rank	Mean	S.D.	Number	Benchmarks
54	3.042	0.550	104	Be able to interpret and evaluate the accuracy of the information obtained and determine if it is useful. Be able to synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.
55	3.000	0.511	54	Knowing that transportation vehicles made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.
56	3.000	0.511	71	Understand that design goals and requirements must be established and constraints must be identified and prioritized during the time when designs are being developed. Knowing that the process of engineering design takes into account a number of factors (such as: safety, function, flexibility, quality, and economic, political, and cultural concerns).
57	3.000	0.417	18	Understand that access to and ability to use tools, materials, and skills limits technological development. Demonstrate the ways that multiple resources (such as people, information, tools and machines, techniques, materials, energy, capital, and time) are used to develop new technologies.
58	2.958	0.550	82	Knowing that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.
59	2.917	0.408	70	Able to explain how products are manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The cost associated with these functions may introduce yet more constrains on the design
60	2.917	0.504	55	Knowing that transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.

Table 4.8: The non-important benchmarks viewed by the expert panel, results of the Delphi studies. Rank ordered according to their mean rating. N= 24.

Rank	Mean	S.D.	Number	Benchmarks
1	2.8333	0.637	2	Appraise how corporations can often create a demand for a product by bringing it onto the market and advertising it; Support the idea that marketing involves informing the public about a product as well as establishing the product's identity, conducting research on its potential, advertising it, distributing it, and selling it.
2	2.7917	0.5882	86	Be able to troubleshoot, analyze, and maintain system to ensure safe and proper function and precision.
3	2.7917	0.779	3	Interpret how creative thinking and economic and cultural influences shape technological development.
4	2.7917	0.779	37	Gather and organize information to create a database of historical events in technology development. Illustrate how technology has evolved throughout human history.
5	2.75	0.6079	9	Knowing that systems, which are building blocks of technology, are embedded within larger technological, social, and environmental systems. The stability of a technological system is influenced by all of the components in the system.
6	2.6667	0.637	77	Knowing that requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.
7	2.625	0.7109	76	Knowing that established design principles should be used to evaluate existing designs, to collect data, and to guide the design process. Be able to evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.
8	2.625	0.7697	17	Knowing that an infrastructure is the basic framework of a system, which includes buildings, services, and installations needed for a government to function, such as transportation, communication, water, energy, and public information system.
9	2.5417	0.7211	48	Knowing that the sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures. Therefore, it is necessary to establish ethical mandates for regulating the incidence of testing and the uses of test results.

Continued

Table 4.8: Continued.

Rank	Mean	S.D.	Number	Benchmarks
10	2.4583	0.509	40	Knowing that the specialization of function has been at the heart of many technological improvements.
11	2.4583	0.509	68	Understand that: Structures are constructed using a variety of processes and procedures. Structures require maintenance, or renovation periodically to improve them or to alter their intended use.
12	2.4167	0.5036	44	Knowing that agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products and in the care of animals.
13	2.4167	0.5036	83	Describes and implements basic troubleshooting techniques for multimedia computer systems with related peripheral devices.
14	2.4167	0.5836	43	Knowing that medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. Medical technologies extend the effectiveness of medical care and increase people's wealth.
15	2.4167	0.6539	105	Knowing that systems thinking applies logic and creativity with appropriate compromises in complex real-life problems and involves considering how every part relates to others
16	2.375	0.4945	72	Knowing that the design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.
17	2.375	0.5758	101	Be able to explore the emerging technologies and develop the skills to evaluate their impacts by reasoning and making decisions based on asking critical questions.
18	2.375	0.5758	78	Explain how technological inventions and innovations stimulate economic competitiveness and how, in order for an innovation to lead to commercial success, it must be translated into products and services with marketplace demand. Explain through examples how some inventions are not translated into products and services with market place demand, and therefore do not become commercial successes. Describe the process that an inventor must follow to obtain a patent for an invention.

Continued

Table 4.8: Continued.

Rank	Mean	S.D.	Number	Benchmarks
19	2.3333	0.5647	96	Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget. Knowing that quality control is a planned process to ensure that a product, service, or system meets established criteria
20	2.2917	0.55	67	Knowing that the product design utilizes a broad range of manufacturing processes, such as metal forming, injection molding, rapid tooling, machining, abrasive water jet cutting, and finishing operations.
21	2.25	0.6757	95	Describe new management techniques (e.g., computer-aided engineering, computer-integrated manufacturing, total quality management, just-in-time manufacturing), incorporate some of these in a technological endeavor, and explain how they have reduced the length of design-to-manufacture cycles, resulted in more flexible factories, and improved quality and customer satisfaction.
22	2.1667	0.5647	49	Knowing that artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals
23	2.125	0.4484	21	Understand that an open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.
24	2.0833	0.5036	79	Be able to use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. Design forecasting techniques to evaluate the results of altering natural systems.
25	2.0833	0.4082	87	Demonstrate the ability to select, operate, maintain, troubleshoot, and dispose of technological devices in the context of a career (e.g., use the tools of accounting in a real or simulated business environment.)
26	2.0833	0.4082	97	Help to manage a group engaged in planning, designing, implementation, and evaluation of a project to gain understanding of the management dynamics.

RESEARCH QUESTIONS

The purpose of the present study was to identify essential benchmarks of technological literacy required of 9th graders in Taiwan, and to determine assessment for these benchmarks. Four research questions were posed:

1. What would be the appropriate benchmarks to assess technological literacy in the area of “development of technology,” a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan?
2. What would be the appropriate benchmarks to assess technological literacy in the area of “design and make," a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan?
3. What would be the appropriate benchmarks to assess technological literacy in the area of "thinking skills," a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan?
4. What would be the appropriate assessment tasks to assess technological literacy a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan?

According to the ROC 2000 National Curriculum Standard, the three categories of technological literacy include: “development of technology,” “design and make,” and "thinking skills." The panel of experts did not agree with this classification. They proposed that the category "development of technology" should be changed to "understanding of technology," the category "thinking skills" should be changed to "inquiry and analytical skills," and "design and make" should be divided into three categories: "design and build skills," "application and problem-solving skills," and "communication skills."

In order to classify the 60 benchmarks identified in this study into the above five different categories of technological literacy, a content analysis was conducted. The process involved identifying keywords in each benchmark and then grouping benchmarks possessing the same concept or ideas. Based on the content analysis, the following number of benchmarks for each category of technological literacy was generated.

The Understanding of Technology	27 benchmarks (see Table 4.9)
Inquiry and Analytical Skills	13 benchmarks (see Table 4.13)
Design and Build	5 benchmarks (see Table 4.10)
Application and Problem-Solving Skills	9 benchmarks (see Table 4.11)
Communication Skills	5 benchmarks (see Table 4.12)

The highest mean rating (3.79) of all the 60 benchmarks was benchmark 69, "To follow directions to assemble or disassemble a product and discover how things work." The two lowest ranked (2.92) benchmarks for which consensus was achieved were benchmark 55 "Understand the interrelationship of transportation with other technologies" with a mean of 2.92, and benchmark 70 "Explain how products are manufactured, operated, maintained, and disposed of," with a mean of 2.92. When scrutinizing those important benchmarks against those non-important benchmarks on the list of tentative benchmarks, three distinctive reactions/responses of the panelists were found:

a). No benchmark (from 43 to 49) related to agricultural, medical, or biotechnology was viewed as important by the panel of experts. The traditional classification of science education and technology education in Taiwan may contribute to this result.

b). Another interesting finding is that those benchmarks (e.g. 2, 9, 17, 21, 26, 39, 58, 71 and 77) with keywords such as systems, processes, corporations, society, and constraints were all viewed as non-important. It is probably because panelists who are using Chinese as their main language do not use these terms in constructing and conveying their ideas.

c). If the 105 proposed benchmarks were divided into only two categories: "To be able to understand some concepts," and "To be able to do something," then the former category would be tending to be viewed as non-important. It is probably because panelists, based on traditional educational perception, believe that the major goal of technology education is to equip students with the ability to do something.

Research Question 1

What would be the appropriate benchmarks to assess technological literacy in the area of "development of technology," a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan? The question can be answered with the findings of this study.

Among the 27 benchmarks of "understanding of technology", benchmark 33 "Understand that humans can devise technologies to conserve water, soil, and energy," with mean of 3.67, is the most important benchmark in this category. On the other hand, benchmark 55, "Understand the interrelationship of transportation with other technologies," with a mean of 2.92, is the least important benchmark in this category.

Table 4.9: The Benchmarks of "Understanding of Technology," results of the three-round Delphi, (N= 24).

Rank	Mean	S.D.	Number	Benchmarks
1	3.67	0.48	33	Understand that humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.
2	3.58	0.58	56	Knowing what technologies are using to conserve the natural energy resources, and what approaches can be employed to use energy more efficiently in daily living.
3	3.54	0.59	12	Knowing that people's needs and wants lead to the manufacturing of products, and when people's need and wants change, new technologies are developed.
4	3.54	0.59	23	Understand that decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.
5	3.50	0.72	8	Understanding that technological systems include input, processes, output, and, at times, feedback; they work together to accomplish a goal.
6	3.50	0.66	10	Understanding what in their world is natural and what is human made, and knowing that new technology is developed to solve problems and change the world around us.
7	3.50	0.51	15	Knowing that resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.
8	3.50	0.66	19	Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.
9	3.50	0.66	31	Knowing that technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.
10	3.46	0.51	24	Understand that technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.

Continued

Table 4.9: Continued.

Rank	Mean	S.D.	Number	Benchmarks
11	3.42	0.50	11	Be able to define technology encompassing past, present, and future developments and provides significant details and examples to illustrate the definition of technology.
12	3.38	0.65	64	Knowing that buildings generally contain a variety of subsystems, such as utilities systems, they are: water, electrical, plumbing, gas, waste disposal, heating and air conditioning, information and communication, as well as component systems, such as foundations, framing, insulation, and lighting.
13	3.33	0.70	22	Understand that ethical considerations are important in the development, selection, and use of technologies. Describe personal consequences for the inappropriate or unethical use of technology.
14	3.29	0.55	7	Illustrate how people generate new products and systems through creativity and innovation to meet their needs
15	3.29	0.46	14	Knowing that the development and use of technology influence economic, political, social, cultural, and ethical issues .
16	3.29	0.55	30	Describe the important technology inventions that have had significant impacts on human beings. Knowing that the use of inventions and innovations has led to changes in society and the creation of new needs and wants. Explain how technological inventions and innovations have caused global growth and interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete.
17	3.29	0.55	38	Knowing that in the past, an invention or innovation was not usually developed with the knowledge of science. In fact, much science knowledge is being gathered alongside the technological development.
18	3.29	0.69	53	Knowing that power systems are used to drive and provide propulsion to other technological products and systems. Power systems must have a source of energy, a process, and loads.
19	3.29	0.75	57	Knowing that the design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.

Continued

Table 4.9: Continued.

Rank	Mean	S.D.	Number	Benchmarks
20	3.25	0.53	51	Knowing that energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.
21	3.17	0.56	27	Knowing that social and cultural priorities and values are reflected in technological devices. In other words, meeting societal expectations is the driving force behind the acceptance and use of products and systems. Understand that the management of waste produced by technological systems is an important societal issue
22	3.13	0.45	13	Knowing that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.
23	3.083	0.584	65	Knowing that manufacturing processes include designing products, gathering resources, and using tools to separate, form, combine materials in order to produce products, and servicing of products and systems. Servicing is included because it keeps products in good operating condition.
24	3.042	0.464	1	Justify the study of technology uses many of the same ideas and skills as other subjects; and the knowledge gained from other fields of study has a direct effect on the development of technological products and systems; Defend that technologies are often combined. Various relationships exist between technology and other fields of study.
25	3.000	0.511	54	Knowing that transportation vehicles made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.
26	3.000	0.417	18	Understand that access to and ability to use tools, materials, and skills limits technological development. Demonstrate the ways that multiple resources (such as people, information, tools and machines, techniques, materials, energy, capital, and time) are used to develop new technologies.
27	2.92	0.5036	55	Knowing that transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.

Research Question 2

What would be the appropriate benchmarks to assess technological literacy in the area of “design and make," a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan?

There are 19 benchmarks of technological literacy in the area of “design and make” identified in this study. They are divided into three subcategories: “design and build skills”, “application and problem-solving skills”, and “communication skills” as shown in Tables 4.10, 4.11, and 4.12, respectively.

Among the 5 benchmarks of “design and build skills”, benchmark 69 “To follow directions to assemble or disassemble a product and discover how things work,” is the highest ranked benchmark. In fact, it is the highest ranked benchmark of all the 60 benchmarks (mean over 3.79 in a scale where 4 represents the most important). This indicates a strong agreement that “design and build skills” is the most important subcategory of technological literacy.

In contrast, benchmark 70 “to explain how products are manufactured, operated, maintained, and disposed of,” with a mean of 2.92, is the least important benchmark in this subcategory.

Rank	Mean	S.D.	Number	Benchmarks
1	3.792	0.509	69	Be able to follow step-by-step directions to assemble or disassembly a product, observe, and discover how things work.
2	3.458	0.721	73	Knowing that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. To be able to express ideas to others verbally and through sketches and models, cause it is an important part of the design process.
3	3.333	0.702	74	Knowing that the design processes include (1) defining a problem, (2), researching and generating ideas by brainstorming, (3) identifying criteria and specifying constraints, (4) exploring possibilities, (5) selecting an approach, (6) developing a design
4	3.125	0.448	75	Knowing that a prototype is a working model used to test a design concept by making actual observations and necessary adjustments
5	3.000	0.511	71	Understand that design goals and requirements must be established and constraints must be identified and prioritized during the time when designs are being developed. Knowing that the process of engineering design takes into account a number of factors (such as: safety, function, flexibility, quality, and economic, political, and cultural concerns).
6	2.917	0.408	70	Able to explain how products are manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The cost associated with these functions may introduce yet more constrains on the design

Table 4.10: The Benchmarks of Design and Make – "Design and Build", results of the three-round Delphi, (N= 24).

Among the 9 benchmarks of "application and problem-solving skills," as shown in Table 4.11, benchmark 92 "To use information provided in manuals, to understand how things work" is the highest ranked benchmark. Its high mean rating of 3.78, also proves that reading and application skills are important to technological literacy. In contrast, benchmark 82 "Knowing the function of research and development," with a mean of 2.96, is the least important benchmark in this subcategory.

Rank	Mean	S.D.	Number	Benchmarks
1	3.750	0.532	92	Be able to use information provided in manuals, protocols, or by experienced people to see and understand how things work.
2	3.583	0.776	90	Apply technological concepts and processes to solve practical problems and extend human capabilities.
3	3.583	0.776	91	Demonstrate the ability to work safely, efficiently, cooperatively and independently (ITEA, 2000).
4	3.583	0.654	62	Use technology tools to enhance learning, increase productivity, and promote creativity.
5	3.583	0.504	59	Be able to use computers to access and organize information, or use it in various applications. Use technology to locate, evaluate, and collect information from a variety of sources. Use technology tools to process data and report results.
6	3.542	0.588	98	Be able to select and safely use tools, products, and systems for specific tasks.
7	3.417	0.717	89	Understand that maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.
8	3.304	0.765	85	Be able to use tools, materials, and machines safely to diagnose, adjust, and repair systems.
9	2.958	0.550	82	Knowing that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.

Table 4.11: The Benchmarks of Design and Make – “Application and Problem-Solving”, results of the three-round Delphi, (N= 24).

Among the five benchmarks of “communication skills,” as shown in Table 4.12, benchmark 61 “To communicate using verbal, graphic, and other means,” with mean of 3.54, is the highest ranked benchmark. In contrast, benchmark 63 “To use a variety of media and formats to communicate,” with mean of 3.21, is the least important benchmark in this subcategory.

Rank	Mean	S.D.	Number	Benchmarks
1	3.542	0.658	61	Be able to communicate observation, processes, and results of the entire design processes, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.
2	3.500	0.659	60	Use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.
3	3.458	0.658	94	Be able to recognize and use common symbols, such as graphic symbols, signals, and icons, to communicate key ideas.
4	3.333	0.702	93	Knowing that technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.
5	3.250	0.442	63	Use a variety of media and formats to communicate information and ideas effectively to multiple audiences

Table 4.12: The Benchmarks of Design and Make – "Communication Skills", results of the three-round Delphi, (N= 24).

Research Question 3

What would be the appropriate benchmarks to assess technological literacy in the area of "thinking skills," a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan?

Thirteen benchmarks of technological literacy in the area of "thinking skills" were identified in this study, as shown in Table 4.13. Among them, benchmark 6 "To criticize how the use of technology affects humans in various ways," with mean of 3.63, is the highest ranked benchmark. In contrast, benchmark 104 "To interpret and evaluate the accuracy of information obtained," with mean of 3.04, is the least important benchmark in this category.

Rank	Mean	S.D.	Number	Benchmarks
1	3.63	0.58	6	Criticize the use of technology affects humans in various ways, including their safety, comfort, choices, lifestyles, and attitudes about technology's development and use.
2	3.61	0.58	88	Identify, select, and use appropriate resources to solve problems.
3	3.42	0.65	99	Be able to brainstorm people's needs and wants and pick some problems that can be solved by technology and through the design process.
4	3.38	0.647	32	Explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.
5	3.38	0.77	35	Explains the interrelationships or connections between technologies and describe how technology has affected the environment and society.
6	3.33	0.48	28	Able to investigate and assess the influence of a specific technology on the individual, family, community, and environment.
7	3.21	0.41	4	Support that Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.
8	3.17	0.38	42	Be able to identify trends and monitor potential consequences of technological development.
9	3.13	0.45	5	Validate that technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.
10	3.13	0.54	16	Able to explain how complex technological systems involve the confluence of numerous other systems. Explain how the submarine or airplanes involves communication, transportation, bio-technology, and manufacturing systems
11	3.13	0.54	102	Be able to test and evaluate the solutions for the design problem in relation to pre-established requirements, and then improve the design solutions or refine the design as needed.
12	3.08	0.50	100	Knowing that asking questions and making observations helps a person to figure out how things work. Besides, Knowing that the process of experimentation, which is common in science, can also be used to solve technological problems.
13	3.04	0.55	104	Be able to interpret and evaluate the accuracy of the information obtained and determine if it is useful. Be able to synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.

Table 4.13: The Benchmarks of "Thinking Skills," results of the three-round Delphi, (N= 24).

Research Question 4

What would be the appropriate assessment tasks to assess technological literacy, a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan?

As shown in Table 4.14, the appropriate assessment methods for assessing technological literacy in the area of "development of technology" includes oral presentations, essay tests, and portfolios. The appropriate assessment methods for assessing technological literacy in the area of "thinking skills" includes portfolios, essay tests, and projects.

		Teacher's observations	Oral presentations	Essay tests	Projects	Portfolios
Understanding of Technology	Round I	8	21	21	6	13
	Round II	4	21	24	4	10
	Round III	3	24	23	2	12
Design and Build Skills	Round I	22	2	3	19	16
	Round II	23	2	1	24	16
	Round III	24	0	0	24	13
Application and Problem-Solving Skills	Round I	19	9	7	18	17
	Round II	22	2	1	22	17
	Round III	23	1	0	23	14
Communication Skills	Round I	16	17	18	14	11
	Round II	14	20	20	11	6
	Round III	13	24	21	10	2
Inquiry and Analytical Skills	Round I	10	13	20	17	20
	Round II	5	9	23	13	21
	Round III	0	6	24	14	24

Table 4.14: The appropriate assessment tasks for three categories of technological literacy, results of the three-round Delphi, (N= 24).

Table 4.15: The important benchmarks and appropriate assessment tasks for the five categories of technological literacy, results of the three-round Delphi, (N= 24).

Categories	Important Benchmarks	Appropriate Assessment Tasks
Understanding of Technology	Understand that humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.	Oral presentations and Essay tests,
	Knowing what technologies are using to conserve the natural energy resources, and what approaches can be employed to use energy more efficiently in daily living.	
	Knowing that people's needs and wants lead to the manufacturing of products, and when people's need and wants change, new technologies are developed.	
	Understand that decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.	
	Understanding that technological systems include input, processes, output, and, at times, feedback; they work together to accomplish a goal.	
	Understanding what in their world is natural and what is human made, and knowing that new technology is developed to solve problems and change the world around us.	
	Knowing that resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.	
	Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.	
	Knowing that technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.	
	Understand that technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.	

Continued

Table 4. 15: Continued.

Understanding of Technology	Be able to define technology encompassing past, present, and future developments and provides significant details and examples to illustrate the definition of technology.	Oral presentations Essay tests, and Portfolios
	Knowing that buildings generally contain a variety of subsystems, such as utilities systems, they are: water, electrical, plumbing, gas, waste disposal, heating and air conditioning, information and communication, as well as component systems, such as foundations, framing, insulation, and lighting.	
	Understand that ethical considerations are important in the development, selection, and use of technologies. Describe personal consequences for the inappropriate or unethical use of technology.	
	Illustrate how people generate new products and systems through creativity and innovation to meet their needs	
	Knowing that the development and use of technology influence economic, political, social, cultural, and ethical issues .	
	Describe the important technology inventions that have had significant impacts on human beings. Knowing that the use of inventions and innovations has led to changes in society and the creation of new needs and wants. Explain how technological inventions and innovations have caused global growth and interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete.	
	Knowing that in the past, an invention or innovation was not usually developed with the knowledge of science. In fact, much science knowledge is being gathered alongside the technological development.	
	Knowing that power systems are used to drive and provide propulsion to other technological products and systems. Power systems must have a source of energy, a process, and loads.	
	Knowing that the design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.	

Continued

Table 4.15: Continued.

Understanding of Technology	Knowing that energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.	Oral presentations Essay tests, and Portfolios
	Knowing that social and cultural priorities and values are reflected in technological devices. In other words, meeting societal expectations is the driving force behind the acceptance and use of products and systems. Understand that the management of waste produced by technological systems is an important societal issue	
	Knowing that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.	
	Knowing that manufacturing processes include designing products, gathering resources, and using tools to separate, form, combine materials in order to produce products, and servicing of products and systems. Servicing is included because it keeps products in good operating condition.	
	Justify the study of technology uses many of the same ideas and skills as other subjects; and the knowledge gained from other fields of study has a direct effect on the development of technological products and systems; Defend that technologies are often combined. Various relationships exist between technology and other fields of study.	
	Knowing that transportation vehicles made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.	
	Understand that access to and ability to use tools, materials, and skills limits technological development. Demonstrate the ways that multiple resources (such as people, information, tools and machines, techniques, materials, energy, capital, and time) are used to develop new technologies.	
	Knowing that transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.	

Continued

Table 4.15: Continued

Inquiry and Analytical Skills	Criticize the use of technology affects humans in various ways, including their safety, comfort, choices, lifestyles, and attitudes about technology's development and use.	Essay tests, Portfolios, and Projects
	Identify, select, and use appropriate resources to solve problems.	
	Be able to brainstorm people's needs and wants and pick some problems that can be solved by technology and through the design process.	
	Explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.	
	Explains the interrelationships or connections between technologies and describe how technology has affected the environment and society.	
	Able to investigate and assess the influence of a specific technology on the individual, family, community, and environment.	
	Support that Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.	
	Be able to identify trends and monitor potential consequences of technological development.	
	Validate that technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.	
	Able to explain how complex technological systems involve the confluence of numerous other systems. Explain how the submarine or airplanes involves communication, transportation, bio-technology, and manufacturing systems	
	Be able to test and evaluate the solutions for the design problem in relation to pre-established requirements, and then improve the design solutions or refine the design as needed.	

Continued

Table 4.15: Continued.

Inquiry and Analytical Skills	Knowing that asking questions and making observations helps a person to figure out how things work. Besides, Knowing that the process of experimentation, which is common in science, can also be used to solve technological problems.	Essay tests, Portfolios, and Projects
	Be able to interpret and evaluate the accuracy of the information obtained and determine if it is useful. Be able to synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.	
Design and Build Skills	Be able to follow step-by-step directions to assemble or disassembly a product, observe, and discover how things work.	Teacher's observations, Projects, and Portfolios
	Knowing that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. To be able to express ideas to others verbally and through sketches and models, cause it is an important part of the design process.	
	Knowing that the design processes include (1) defining a problem, (2), researching and generating ideas by brainstorming, (3) identifying criteria and specifying constraints, (4) exploring possibilities, (5) selecting an approach, (6) developing a design	
	Knowing that a prototype is a working model used to test a design concept by making actual observations and necessary adjustments	
	Understand that design goals and requirements must be established and constraints must be identified and prioritized during the time when designs are being developed. Knowing that the process of engineering design takes into account a number of factors (such as: safety, function, flexibility, quality, and economic, political, and cultural concerns).	
	Able to explain how products are manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The cost associated with these functions may introduce yet more constrains on the design	

Continued

Table 4.15: Continued

Application and Problem-Solving Skills	Be able to use information provided in manuals, protocols, or by experienced people to see and understand how things work.	Teacher's observation Projects and Portfolios
	Apply technological concepts and processes to solve practical problems and extend human capabilities.	
	Demonstrate the ability to work safely, efficiently, cooperatively and independently (ITEA, 2000).	
	Use technology tools to enhance learning, increase productivity, and promote creativity.	
	Be able to use computers to access and organize information, or use it in various applications. Use technology to locate, evaluate, and collect information from a variety of sources. Use technology tools to process data and report results.	
	Be able to select and safely use tools, products, and systems for specific tasks.	
	Understand that maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.	
	Be able to use tools, materials, and machines safely to diagnose, adjust, and repair systems.	
	Knowing that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.	
Communication Skills	Be able to communicate observation, processes, and results of the entire design processes, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.	Oral presentation And Essay tests
	Use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.	
	Be able to recognize and use common symbols, such as graphic symbols, signals, and icons, to communicate key ideas.	
	Knowing that technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages.	
	Use a variety of media and formats to communicate information and ideas effectively to multiple audiences	

The appropriate assessment methods for assessing technological literacy in both "design and build skills" and “application and problem-solving skills” are projects and teacher’s observations. The appropriate assessment methods for assessing technological literacy in the area of "communication skills" include oral presentations and essay tests. Taken as a whole, the appropriate assessment methods for assessing technological literacy in the area of "design and make" are primarily teacher’s observations and projects. But, when communication skills are a major concern, oral presentations and essay tests should be used instead.

Summary

In summary, the perceptions of experts toward the benchmarks and assessment methods for technological literacy required of 9^{th} graders in Taiwan were examined in this exploratory study. Its results, the clarification of a set of benchmarks of technological literacy as well as appropriate assessment tasks, can provide an operational foundation for teaching, learning, measuring achievement, and evaluating technology education.

The results of this study showed that 60 of the 105 benchmarks listed in the questionnaires were rated as important or very important. As can be seen in Table 4.15, twenty-seven of the 60 benchmarks related to the understanding of technology, 13 benchmarks related to thinking skills, and the remaining 20 benchmarks related to the skills of “design and make.” The appropriate assessment tasks for each benchmark also are shown in the right column of Table 4.15. Survey responses came from 24 technology coordinators, teacher educators, and administrators in Taiwan. The most important benchmarks of technological literacy dealt with the interpretation of technical materials to assemble or disassemble a product and discovering how things work.

Second, the 60 benchmarks were classified into five categories: 27 benchmarks related to the understanding of technology (from Table 4.9), 13 benchmarks related to thinking skills (from Table 4.13), nine benchmarks related to application and problem-solving skills, six benchmarks related to design and build skills, and the remaining five benchmarks related to communication skills (from Tables 4.10 – 4.12). Thirdly, appropriate assessment tasks for measuring each category of the above benchmarks were identified. Fourth, none of the benchmarks related to agricultural, medical, or biotechnological skills was viewed by the panel as important. Last, those benchmarks related to doing something were viewed more important than those benchmarks related to knowing something.

CHAPTER 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purposes of this study are to determine the benchmarks of technological literacy that are required of 9^{th} graders in Taiwan, and to determine appropriate assessment methods for measuring them.

This chapter will present an overview of the study, a brief description of the research procedures used to conduct the study, an explanation of the findings of the studies, a discussion of conclusions and implications drawn from the findings, and a list of recommendations arising from the study.

Overview of the Study

The problem

Technology education in Taiwan has been following in the steps of U. S. since the course of Industrial Arts was introduced into junior high school curricula in 1962. Since then, the course title was changed to "Living Technology" in 1997 and "Natural Science and Living Technology" in 2002 (ROCMOE, 1994).

It is difficult to assess and compare the various forms of instruction in technology education without an accepted or standardized measure of technological literacy (Boser, Palmer, & Daugherty, 1998.) Technology educators in the U.S. have established the Standards for Technological Literacy (ITEA, 2000) to provide a foundation for what technological literacy means and to help guide student progress toward technological literacy.

Due to the insufficiency of the ROC 2000 National Curriculum Guidelines in terms of specific performance criteria for technological literacy, the needs of teachers and students in Taiwan regarding the teaching and learning of technology could not be met. The absence of such understanding also resulted in a lack of clarity of goals and methodologies for classroom instruction.

Technology teachers in Taiwan are facing a shortage of objective assessment criteria in their instructional and assessment practices (Shi, 2002; Ni, 1995; Peang, 1998; Chiang, 2000). Therefore, specific benchmarks of technological literacy required of 9th graders in Taiwan as well as adequate assessment tasks for measuring them need to be identified. To improve the instruction and assessment of the course "Living Technology," benchmarks by which technological literacy can be clearly defined are needed.

<u>The purpose of the study and research questions</u>

Technological literacy has been the focus of the teaching and learning of Living Technology, while benchmarks of technological literacy are the center of implementing curriculum planning, instruction, and assessment. Thus, the purpose of this study was to determine the benchmarks of technological literacy required of 9th graders in Taiwan, so that their technological literacy can be advanced and measured effectively.

In order to achieve the purpose of this study, the following research questions were asked:

1. What would be the appropriate benchmarks to assess technological literacy in the area of “development of technology,” a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan?
2. What would be the appropriate benchmarks to assess technological literacy in the area of “design and make," a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan?
3. What would be the appropriate benchmarks to assess technological literacy in the area of "thinking skills," a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan?
4. What would be the appropriate assessment tasks to assess technological literacy a portion of the Natural Science and Living Technology curriculum, as required by the ROC 2000 National Curriculum Guidelines in Taiwan?

<u>Research procedure</u>

This study was conducted using a modified Delphi technique to identify benchmarks of technological literacy required of 9th graders in Taiwan as well as to determine the appropriate assessment tasks for measuring technological literacy. The study was accomplished through the solicitation of responses from a panel of experts. The panel consisted of 24 leading teachers, educators, and administrators in the field of technology education in Taiwan. All of them had extensive experience in teaching, conducting research, and had contributed to the literature on technology education.

Data were collected via written questionnaires which were distributed and collected through the "secure and promptly delivery" by post office in Taiwan.

An initial survey, Delphi probe, was used to elicit possible benchmarks and assessment tasks for use in the three subsequent questionnaires of the Delphi study. The Delphi probe questionnaire consisted of a prepared list of benchmarks and assessment tasks with open-ended inquiry. The prepared list of benchmarks was developed by the researcher based on the Standards of Technological Literacy (ITEA, 2000) and the Learning Standards for MST (NYSED, 1996).

When the questionnaire was returned from panelists, each benchmark was carefully examined for clarity and accuracy by the researcher. Those benchmarks conveying parallel concepts were integrated. Responses provided by the panel members and the benchmarks appended by the researcher were edited and systematized into 105 benchmarks and five assessment tasks and then organized into a questionnaire for the first round of the Delphi studies.

In round one of the Delphi study, the panelists were asked to rate the 105 benchmarks for importance according to a four-point Likert scale. They could also append new benchmarks as they saw fit. Written responses to open-ended questions in the first round were analyzed qualitatively.

During the Delphi studies, panel members reminded anonymous and communicated directly only with the researcher. Their responses in each round of the Delphi study were statistically processed to calculate the mean score and standard deviation for importance and consensus. All benchmarks that did not reached consensus (standard deviation greater than .78) by the panel remained in the next round questionnaire for further inquiry. To simplify the inquiry, those benchmarks that were judged very important (mean over 3.0) or non-important (mean under 2.55) by the panel did not appear in further questionnaires. Panelists received feedback about their responses with the next round questionnaire and were asked to reconsider their previous judgments and make necessary revision.

The research findings

Sixty out of 105 proposed benchmarks were identified. Based on the consensus of the panel of experts, these benchmarks were perceived as important and were ordered according to their means of importance. They were classified into five categories of technological literacy by using content analysis. The appropriate assessment tasks for these five categories of technological literacy were also determined.

For the category "understanding of technology," 27 benchmarks were identified. They are fundamental concepts of technology such as characteristics of technology, technological systems, evolution of technology, and impact of technology. The most appropriate assessment tasks identified for measuring these technological literacy are oral presentations and essay tests.

For the category "thinking skills," 13 benchmarks were identified. They cover the ability to investigate, interpret, explain, analyze, compare, justify, identify, critique, evaluate, or validate. The most appropriate assessment tasks for measuring these technological literacy were essay tests, portfolios, and projects.

For the category "design and build skills," five benchmarks were identified. They are concerned with the ability to design, to fabricate models or prototypes, to use tools and materials, and to apply engineering design. The most appropriate assessment tasks for measuring technological literacy in this category were teacher's observations, projects, and portfolios.

For the category "application and problem-solving skills," nine benchmarks were identified. They are the ability to access, use, and manage technology, to apply technological concepts and processes, to maintain and troubleshoot, and to solve technological problems. The most appropriate assessment tasks for measuring technological literacy in these skills were teacher's observations and projects.

For the category "communication skills," five benchmarks were identified. They deal with the ability to use media, symbols, and formulas to communicate ideas. The most appropriate assessment tasks for measuring technological literacy in these skills were oral presentations and essay tests.

The five highest ranked benchmarks (means greater than 3.61, and standard deviation lower than .58), indicating the strongest agreement for which consensus was achieved, were benchmarks 69, 92, 33, 6, and 88. Two of these benchmarks were classified as thinking skills. These two benchmarks were 6 "To criticize how the use of technology affects humans in various ways," and 88 "To identify, select, and use appropriate resources to solve problems."

Benchmark 33 "To understand that humans can devise technologies to conserve water, soil, and energy" was classified as "understanding of technology." Benchmark 92 "To use information provided in manuals to see and understand how things work" was classified as "application and problem-solving skills."

Benchmark 69 "To follow directions to assemble or disassemble a product, and discover how things work" was classified as "design and build skills." It had the highest mean rating (3.79) of all the 60 identified benchmarks. The low standard deviation (.51) indicates that consensus was also reached for this benchmark. This finding reflects the fact that "design and build skills" is considered the most important type of technological literacy perceived by technology professionals in Taiwan.

The five lowest ranked benchmarks for which consensus was reached, though still important, were associated with "understanding of technology" (18, 54, 55), "design and build skills" (70), and "application and problem-solving skills" (82).

When benchmarks rated as non-important are compared with those rated as important, it was found that the non-important benchmarks had the following characteristics: (a). Related to the agricultural, medical, or biotechnology, (b). Used keywords such as systems, processes, corporations, society, and constraints, and (c). Emphasized the ability to know something. These phenomena may be due to the influence of traditional educational and cultural perception toward technology by professionals in Taiwan.

Discussion of findings

The primary purposes of this study was to identify essential benchmarks of technological literacy required of 9th graders in Taiwan, and to determine assessment methods for these benchmarks. The researcher felt that had more experts been involved and broader inquiry been carried out, a greater perspective of technological literacy required of junior high students in Taiwan would have been obtained. Furthermore, the researcher expected that the outcome of this study would help to facilitate the instruction and evaluation of the course "Living Technology."

In this study, two other categories of technological literacy, "application and problem-solving skills" and "communication skills," were added to the three categories issued in the ROC 2000 National Curriculum Standard (ROCMOE, 2001), i.e. "development of technology," "design and make," and "thinking skills."

The above classification of technological literacy differs from the study of Fang and Yang (1996), in which technological literacy needed for elementary school students in Taiwan was classified into five categories: the scope of technology, development of technology, the process of technology, the application and evaluation of technology, and the impact of technology.

The identification of 60 benchmarks of technological literacy in this study (see Table 4.9) also differs from many other studies of technological literacy in Taiwan in which technological literacy was sorted confined into four categories of technologies: transportation, information, manufacturing, and construction.

Finally, when the 60 benchmarks identified in this study were compared with the 20 standards released by the Standards of Technological Literacy (ITEA, 2000), it was found that two of the 20 standards, standard 14 “To select and use medical technology,” and standard 15 “To select and use agricultural and related biotechnologies,” were considered non-important by the panel and so were excluded from the 60 benchmarks.

Conclusions

The purpose of this study was to assess the consensus of technology educators toward the required technological literacy of 9th graders in Taiwan, and to determine which assessment task was appropriate to assess this technological literacy. Based upon the results of this study, the following conclusions are presented.

It is concluded that the Delphi technique was an effective way to identify and judge the importance of benchmarks required by 9th graders in Taiwan. The panel of experts in this study was able to judge the importance of benchmarks of technological literacy without the cost or logistics involved in getting such a geographically scattered group together. This technique may prove valuable in identifying benchmarks to be focused upon during the implementation of the new “Living Technology” course in the ROC 2000 National Curriculum Standard in Taiwan.

Analysis of the data from the three-round Delphi study exposed overall shifts in mean scores and standard deviations, indicating that some convergence of opinion. By analyzing the features of those benchmarks that have a high mean score and a low standard deviation, the researcher was able to classify all 60 benchmarks into five categories of technological literacy, as shown in Table 4.15. Among 60 benchmarks, 27 benchmarks related to “understanding of technology,” 13 benchmarks related to “inquiry and analytical skills", nine benchmarks related to "application and problem-solving skills," five benchmarks related to design and build skills, and the remaining five benchmarks related to "communication skills."

Furthermore, based upon the perceived appropriate assessment methods for measuring technological literacy, it is concluded that the assessment tasks of teacher's observations and projects are suitable for measuring "design and build skills" and "application and problem-solving skills." Likewise, essay tests and portfolios are appropriate for measuring "inquiry and analytical skills," essay tests and oral presentations are suitable to measure "understanding of technology," and oral presentations and essay tests are for measuring the communication skills.

The clarification of benchmarks and assessment methods for technological literacy, required of 9th graders in Taiwan, would aid in unraveling the complexities that hinder the teaching and learning of technology. Because the performance criteria of technological literacy is lacking at other educational levels in Taiwan, the results of this study are also applicable to the technology education of primary and secondary schools in Taiwan.

This study defines and prioritizes the primary benchmarks and assessment tasks of technological literacy, which are required by 9th graders in Taiwan. The stability of expert opinion in the three-round Delphi studies lends credence to the validity of the study data. Its findings may add to recent educational literature that demonstrates that identifying benchmarks is valuable to teach and assess performance, skills, and technological literacy.

Recommendations

Some recommendations for application, implementation, and further research arise from the results and conclusions of this study.

Recommendation for Application

The results of this study complement the ROC 2000 National Curriculum Standard and will be sent to the Ministry of Education for dissemination to all technology teachers, educators, and administrators in Taiwan. The appropriate benchmarks and assessment tasks of technological literacy identified in this study can be used as a basis to develop curriculum, to design learning activities, and to perform instruction and evaluation for the technology course "Living Technology."

To effectively disseminate the above research findings, a website should be established, a brochure should be published, and a national workshop inviting principals, administrators, and exemplary technology teachers should be held. The identification of benchmarks and assessment tasks for different categories of technological literacy are common necessities of all schools in Taiwan to implement technology education.

Additionally, the extensive interactions during data collection with many chief technology teachers, educators, and administrators in Taiwan between July 2002 and June 2003 will definitely have a tremendous impact on the technology profession in Taiwan. This impact may contribute to the research and creation of a Taiwanese version of Standards for Technological Literacy, and to the adoption of performance assessment.

Recommendations for the classroom instruction and evaluation

Based on this study, recommendations for the instruction and evaluation of the "Natural Science and Living Technology" course in Taiwan can be derived as follows:

1. The learning activities and classroom instruction of Living Technology should focus on the benchmarks identified in this study, rather than on the textbook, as is prevailing practice today.
2. The evaluation of learning outcomes should highlight the 60 benchmarks identified in this study, rather than the rote memorization of facts or the workmanship of student projects.
3. When measuring technological literacy of students, the range of assessment tasks identified in this study should be applied instead of solely relying on paper-and-pencil tests.

Recommendation for further research

Further research, both quantitative and qualitative in nature, should take place to further investigate the curriculum development, instructional strategies, and performance assessment based on the benchmarks identified in this study.

Currently restricted to the junior high school level, the study should be replicated at the primary school and senior high school levels. Such studies could provide valuable directions for the curriculum development and verify whether the results of this study are generalizable to primary schools and senior high schools levels. Only after all benchmarks of technological literacy for K-12 graders in Taiwan are identified, can the goals and objectives of technology education in Taiwan be clearly recognized.

The different perspectives among technology teachers, teacher educators, and administrators are worthwhile for further investigating. The qualification of participants, such as work experiences and publications, should be reduced to accommodate more participants involved into the study.

Furthermore, a study utilizing the Delphi technique could investigate the perceptions of exemplary principals and administrators in Taiwan about the feasibility and implementation of the standardized tests of technological literacy for all junior high students in Taiwan. Such information would complement that gathered in this study.

Finally, future research should be conducted that builds on the results of this study to determine the appropriate assessment system for measuring technological literacy of K-12 students in Taiwan. The development of assessment tasks, rubrics, implementation procedures, and implication should be of primary significance. This research would add to the growing body of knowledge related to the instruction and assessment of technological literacy of students in Taiwan.

APPENDIX A

COMPOSITION OF DELPHI PANEL

Appendix A. Composition of Delphi Panel

Group	Panel Member	Position
Administrator	Yong-Chung Chang	Dean of Instruction, Sheon-Sung Junior High
Administrator	Wen-Chung Lee	Dean of Instruction, Chung-Ping Junior High
Junior High	Mei-Liang Chen	Tech. Ed. Teacher Lung-Ya Junior High
Junior High	Shin-Ru Lee	Tech. Ed. Teacher Kuei-Jen Junior High
Junior High	Ming-Jei Chang	Tech. Ed. Teacher Lee-San Junior High
Junior High	Ming-Chu Hsu	Tech. Ed. Teacher Wu-Chong Junior High
Junior High	Shern-Ling Chang	Tech. Ed. Teacher Ming-Hoo Junior High
Junior High	Ren-Long Lin	Tech. Ed. Teacher Jin-Hwa Junior High
Junior High	Ja-Wei Hsu	Tech. Ed. Teacher Ming-Hu Junior High
Junior High	Jing-Shong Wang	Tech. Ed. Teacher Ren-Ahi Junior High
Junior High	Ya-May Liang	Tech. Ed. Teacher Sir-Lin Junior High
Junior High	Show-Tan Wei	Tech. Ed. Teacher Lan-Ya Junior High
Senior High	John Hwang	Tech. Ed. Teacher Tai-Chung Senior High
Senior High	Kwen-Yi Lin	Tech. Ed. Teacher Taipei Senior High
Senior High	Chung-Chin Ye	Tech. Ed. Teacher Taipei Chi-Je Senior High
Senior High	Wei-Chi Chen	Tech. Ed. Teacher Ban-Chao Senior High
Senior High	Jen-Hwen Din	Tech. Ed. Teacher Dou-Liu Senior High
Senior High	Hwang-Jao Lai	Tech. Ed. Teacher Chung-shing Senior High
University	Paul Chen Yu	Tech. Ed. Teacher Educator -- Curriculum
University	De-Hung Kao	Tech. Ed. Teacher Educator -- Manufacturing
University	Kung-Chao You	Tech. Ed. Teacher Educator -- Communication
University	Nen-Tong Huang	Tech. Ed. Teacher Educator -- Transportation
University	Sir-Kwan Hsu	Tech. Ed. Teacher Educator -- Construction
University	Chi-Jang Lai	Tech. Ed. Teacher Educator -- Instruction

APPENDIX B.

COMPOSITION OF THE "TECH ED IN TAIWAN" COUNSELING COMMITTEE IN TAIWAN

Appendix B. Composition of the "Tech Ed in Taiwan" counseling committee

Counseling Committee Member	Position
Dr. Lung-Sheng Stephen Lee	Professor Dean of the College of Technology The National Taiwan Normal University
Dr. Chung-Hsiung Fang	Professor Dept. Head of the Industrial Technology Education. The National Taiwan Normal University
Dr. Chien Yu,	Professor Former Head of Department of Industrial Tech. Ed. The National Taiwan Normal University
Dr. David Lee,	Professor Former Dean of Instruction. The National Taiwan Normal University
Dr. Shi-Tow Ted Tsai	Professor Dept. Head of the International Human Development The National Taiwan Normal University
Dr. Kuo-hung Tseng	Professor Former Dept. Head of the Industrial Technology Ed. The National Kao-Hsiung Normal University

APPENDIX C.

PHONE SCRIPT IN OBTAINING ORAL CONSENT

Appendix C Phone Script in obtaining Oral Consent

-
- Hi, are you Mr/Mrs. ….?
- Congratulations. As a distinguished technology educator/teacher, You are nominated by Dr. Lung-Sheng Steven Lee, Dr. Shi-Tow Ted Tsai, and Dr. Chung-Hsiung Fang to be one member of the panel of experts. Although you had agreed that you would partake this study, I still want you to know more about your rights in participating to this study.
- First, let's me introduce myself. I am Kung Fu Sunny Wang, (old teacher Wang). (Maybe you had already known me.) After teaching for 34 years, including teaching at National Taiwan Normal University since 1979, I enrolled the program of Math, Science, and Technology Education of the Ohio State University to learn more advanced theories and principles of technology education, and currently I am a Ph.D. candidate.
- Second, the purpose of the research is to identify the benchmarks of technological literacy for ninth graders of junior high school students in Taiwan, and to determine the appropriate authentic assessment methods. In other words, the goal of this study is to determine what content and level of technological literacy is expected from ninth graders in Taiwan and how to assess it.
- The expected duration of your participation in from June 20 to December 20, 2002.
- A three-round Delphi technique is the procedure used to conduct this study.
- Third, the questionnaire is comprised of 105 benchmarks, which are tentative constituents of technological literacy expected from ninth graders in Taiwan. To develop a model performance assessment system, this questionnaire is to identify the most important benchmarks and assessment methods for technological literacy consistent with the new national curriculum.
- The benefits you may enjoyed as one of the panel of experts include understanding the consensus of other experts of technology education, receiving the final report of the study, and becoming a team member of my future researches.
- The ideas and opinions you reply in the questionnaire will never be connected with your name and exposed to anyone or published on the dissertation. I personally guarantee that the confidentiality of records identifying the subject will be maintained. If injury occurs due to reply to participate this study and reply to the questionnaire, I will give you compensation. You can reach me at 614-688-9775.
- You can contact Technology Education Program director, Dr. Paul E. Post at 614-292-7471, or The Office of Research Risks Protection at 614-292-6950 for answers to pertinent questions about the research and research subject's rights.
- You are free to quit from this study any time you would like without penalty or loss of benefits to which you are otherwise entitled.
- Finally, you can refuse to answer individual questions as well as any question that deals with sensitive issues (including but not limited to, illegal behavior, mental status, sexuality or sexual abuse, drug or alcohol use.)
- Nice to talk with you.

APPENDIX D.

A DATA-COLLECTION INSTRUMENT FOR INTERVIEW

Appendix D The Instrument for Interview by Phone or in Person

[Question]: Will you participate the study?

- The purposes of the research will be explained to the interviewee that they are to identify the benchmarks of technological literacy for ninth graders of junior high school students in Taiwan, and to determine the appropriate authentic assessment methods.

[Question]: After reviewing the list of benchmarks, what other benchmarks would you suggest?

- A list of 100 tentative benchmarks will be presented.

[Question]: How would you classify the benchmarks of technological literacy?

- A list of 15 categories will be presented.

[Question]: How would you assess technological literacy other than paper-and-pencil tests?

- Part of the list of possible assessment methods will be presented as below:

Portfolio (Student) Projects/Design Project
Essays Oral Presentation
Teacher Observation Theme Studies/Research Papers
Problem-Solving Logs Work Experience Descriptions
Self-Assessment Instruments Peer Critiques
Bulletin Board Ideas Anecdotal Records

[Question]: How would you grade your student (what is your grading system)?

- A list of possible grading systems with a variety of weight of different tasks are presented as below:

Assessment tasks	Percentage of scoring		
	Plan #1	Plan #2	What is your plan?
Multiple choice test	26%	30%	
Essay test	10%	15%	
Oral presentation	15%	12%	
Teacher observation	12%	10%	
Projects/exhibitions	16%	13%	
Portfolios	21%	20%	
Total score	100%	100%	100%

[Question]: What are your perspectives of measuring technological literacy in assessment practice in Taiwan, such as benchmarks and assessment tasks?

- An open question will be asked to investigate the prevailing assessment tasks, tests, and rubrics used, and on the influential stakeholders' convictions in regard to the assessment of technological literacy in Taiwan.

APPENDIX E.

INTRODUCTORY LETTER TO PANELISTS

Appendix E An Introductory Letter to Panelists

Dear Mr/Mrs. _________,

As a distinguished technology educator/teacher, You are nominated by Dean College of Technology Education, Dr. Lung-Sheng Steven Lee, and Department Chair of Industrial Technology Education, Dr. Chung-Hsiung Fang to be a member of the panel of experts.

I am a Ph.D. candidate of the program of Math, Science, and Technology Education of the Ohio State University. After teaching for 30 years in Taiwan, I enrolled this program to learn more advanced theories and principles of technology education. The goal of this study is to determine what content and level of technological literacy are expected from ninth graders in Taiwan and how to assess them. To develop a model performance assessment system, the first questionnaire is to identify the most important benchmarks, and the second questionnaire is to identify the assessment methods for technological literacy consistent with the new ROC 2000 National Curriculum.

Thank you for the participation of the three-round Delphi studies. You will be participating in multiple administrations of questionnaires (to rate the items and reconsider your answers based on team decision I send back to you, more than once.) As I told you over phone, you may receive eight E-mails from me at most. Your participation of this study will provide valuable information on the assessment of technological literacy.

I personally guarantee the confidentiality of your answers and information, and will give you compensation if injury occurs to you due to participate the study. You can reach me at 614-688-9775, the Technology Education Program director, Dr. Paul E. Post at 614-292-7471, or The Office of Research Risks Protection at 614-292-6950 for answers of pertinent questions about the research and research subject's rights. Thanks.

Yours Faithfully,
Kung Fu Sunny Wang

The above cover letter of questionnaire #1 had been reviewed. I would be interested in being a member of the panel of expert to explore the benchmarks of technological literacy of 9th graders in Taiwan as well as the appropriate non-traditional assessment methods for measuring these benchmarks.

Signature：______________________________

<煩請簽名，表示同意擔任本研究諮詢專家>

APPENDIX F.

RECOMMENDATION LETTER FROM DEPARTMENT CHAIR TO PANELISTS

Appendix F　Recommendation Letter from Department Head to Panelists

親愛的科技教育專家：

您好，感謝您參與本研究。本問卷擬就國中三年級學生應該具備何種 “科技能力”，以及這些能力應該採用那些“非傳統紙筆測驗方法”，請您惠賜高見。本研究採德懷術方法，一共分三次徵求意見，其間會把大家的意見彙整後提供您參考。爲三次諮詢流程耽誤 您寶貴時間，敬致由衷謝意。

爲謀深入探究專家對本問卷問題之見解，本研究擬將諮詢流程安排如下：

4 月 **2** 日	首輪問卷寄回
4 月 **16** 日	第二輪問卷寄回
4 月 **30** 日	第三輪問卷寄回

問卷首頁之同意函(同意擔任本研究諮詢專家)煩請簽字，與問卷一併擲回。本問卷共 **16** 頁； 此一首輪問卷擬請盡速填寫並於 **4** 月 **2** 日(三)前以「限時掛號」寄回所附地址爲感。

再次感謝您的協助！

敬祝　　道　安

國立台灣師範大學工業科技教育學系

系主任 方崇雄教授

APPENDIX G

DELPHI PROBE

Appendix G Delphi Probe – A Follow-up Letter

Introduction:

This letter is written specially for some of you who prefer correspondence with letter. The researcher of this study is certainly open to suggestions and comments about specific aspects of this study, or any of your thoughts on the benchmarks and assessment methods for technological literacy that you think I should cover. I do want, however, to retain the basic theme of the study: to determine the most appropriate benchmarks and assessment tasks required of 9th graders in Taiwan.

Instruction:

A proposed list of 150 benchmarks was sent to you for examination last month through e-mail. We will send it again if you ask. Responses had been analyzing and we are still hoping more feedback from you. You can either send your comment by a letter or by e-mail to us.

The 150 benchmarks were classified as 10 benchmarks in each of the 15 tentative categories of technological literacy. Please select three most irrelevant or non-important benchmarks out the ten benchmarks within each category, add new benchmarks for each category if necessary, and then reply by e-mail to t83001@cc.ntnu.edu.tw by August 31, 2002. Based on your judgment, a total of 105 benchmarks, in which 7 benchmarks in each of the 15 categories will be compiled.

Sincerely,

Kung Fu Sunny Wang
Ph.D. Candidate
The Ohio State University

APPENDIX H

QUESTIONNAIRE FOR FIRST-ROUND OF DELPHI STUDY

<u>Appendix H Questionnaire for first-round of Delphi study</u>

Dear Panel Member,

In this questionnaire we will be asking you, what you think of the most important benchmarks of technological literacy of 9th graders in Taiwan. We will also be seeking your opinions on the most appropriate assessment methods to evaluate their technological literacy other than paper and pencil test.

親愛的科技教育專家：

本問卷擬就國中三年級學生應該具備何種科技能力，以及那些非傳統紙筆測驗方法、較値得採行等項目進行討論，請惠予以表示高見。採德懷術方法，一共分三次徵求意見，其間會把大家的意見彙整後供您酌參。

<u>[Question #1]: The Benchmarks of technological literacy needed by 9th graders in Taiwan</u>

([問題 #1]: 徵詢 國中三年級學生 科技能力之重要指標)

Instruction：

Please select the importance of following potential benchmarks according to the scale -

4 if you felt this is a very important benchmark of technological literacy
3 if you felt this is an above average importance benchmark of technological literacy
2 if you felt this is a below average importance benchmark of technological literacy
1 if you felt this is a very unimportant benchmark of technological literacy

表達方式：

請最左側空格裏<**4,3,2,1**>四個數字間選擇一個數字加以圈選，來表達您對下列各技能指標重要性的看法：

<**4**>代表最重要，<**3**>代表還算重要，<**2**>代表不太重要，<**1**>代表最不重要

Category 類別	**Item #** 編號	<Example>： *To be able to go to library and to write a summary of what he/she found.* <舉例>： **(會：上圖書館查資料、並寫出心得摘要)**	<Example> 4 3 (2) 1

Questions are in next page

<以上為舉例，以下為正式問卷>

Category 類別	**Item #** 編號	**Benchmarks** 技能指標	**Importance** 重要性

The characteristics and scope of technology 科技的範圍及特性	1	*Justify the study of technology uses many of the same ideas and skills as other subjects; and the knowledge gained from other fields of study has a direct effect on the development of technological products and systems; Defend that technologies are often combined. Various relationships exist between technology and other fields of study.* 能說明科技的發展其他學科密切相關，是採用類似的方法來發展的，且各類科技之間也是息息相關	**4**	**3**	**2**	**1**
	2	*Appraise how corporations can often create a demand for a product by bringing it onto the market and advertising it; Support the idea that marketing involves informing the public about a product as well as establishing the product's identity, conducting research on its potential, advertising it, distributing it, and selling it.* 瞭解: 企業如何創造出人們對產品的需求及行銷手法，能評估科技產品之價值，並以專題研究方式，來研究其市場潛力，如何推廣、發行、銷售	**4**	**3**	**2**	**1**
	3	*Interpret how creative thinking and economic and cultural influences shape technological development.* 能詮釋：創造思考及經濟文化 如何塑造科技之發展	**4**	**3**	**2**	**1**
	4	*Support that Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.* 能說明所謂科技之轉移，是把現有的科技方法或發明，運用於新的用途	**4**	**3**	**2**	**1**
	5	*Validate that technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.* 能說明所謂科技創新往往發生於: 把構想和技術，從某一類科技運用於另一類科技	**4**	**3**	**2**	**1**
	6	*Criticize the use of technology affects humans in various ways, including their safety, comfort, choices, lifestyles, and attitudes about technology's development and use.* 能說明 "使用科技"會影響到人類生活各層面，如安全、舒適、選擇、生活方式、以及改變對科技的態度	**4**	**3**	**2**	**1**
	7	*Illustrate how people generate new products and systems through creativity and innovation to meet their needs (ITEA, 2000).* 能說明: 人類如何應用，創造及更新，來發展更好的產品及系統，來滿足需求	**4**	**3**	**2**	**1**
The core concepts of technology 瞭解科技之核心概念	8	*Understanding that technological systems include input, processes, output, and, at times, feedback; they work together to accomplish a goal.* 瞭解: 科技系統包括輸入、處理、輸出、和回饋，並合力完成系統目標	**4**	**3**	**2**	**1**
	9	*Knowing that systems, which are building blocks of technology, are embedded within larger technological, social, and environmental systems. The stability of a technological system is influenced by all of the components in the system.* 瞭解: 科技是整個社會系統或環境系統的組成部分，它本身是由各類系統組成，各組成部分能決定系統是否穩定	**4**	**3**	**2**	**1**

	10	*Understanding what in their world is natural and what is human made, and knowing that new technology is developed to solve problems and change the world around us.* 瞭解：何爲人造世界、何爲自然世界；而且能說明新科技是用來解決問題及改良世界的	**4 3 2 1**
	11	*Be able to define technology encompassing past, present, and future developments and provides significant details and examples to illustrate the definition of technology.* 瞭解：科技在過去今日及未來的發展，並詳細的界定何謂科技	**4 3 2 1**
	12	*Knowing that people's needs and wants lead to the manufacturing of products, and when people's need and wants change, new technologies are developed.* 瞭解：人類如何因需求而製造，而當需求改變時，新科技因之而發展	**4 3 2 1**
	13	*Knowing that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.* 瞭解：綜觀歷史，科技都是導因於社會、工業、商業、及個人之需求、價值觀、及利益發生了改變	**4 3 2 1**
	14	*Knowing that the development and use of technology influence economic, political, social, cultural, and ethical issues . (ITEA, 2000).* 瞭解：科技之發展運用，對文化、社會、經濟、政治、及倫理之影響	**4 3 2 1**
Tools, resources, systems, technological processes, and relationships 工具資源系統及科技程序之關係	15	*Knowing that resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time.* 瞭解：資源是指完成工作所必需的，譬如工具、機械、材料、資訊、能源、人力、資本、時間等	**4 3 2 1**
	16	*Able to explain how complex technological systems involve the confluence of numerous other systems. Explain how the submarine or airplanes involves communication, transportation, bio-technology, and manufacturing systems (ITEA, 2000).* 瞭解：科技系統是由各類子系統匯集而成，並能舉例說明潛水艇和飛機如何包括通訊、運輸、生物科技、製造等系統	**4 3 2 1**
	17	*Knowing that an infrastructure is the basic framework of a system, which includes buildings, services, and installations needed for a government to function, such as transportation, communication, water, energy, and public information system.* 瞭解：公共建設系統架構爲政府運作所必需，其組成包括如：建築、通訊、供水、能源、公共資訊系統等	**4 3 2 1**
	18	*Understand that access to and ability to use tools, materials, and skills limits technological development. Demonstrate the ways that multiple resources (such as people, information, tools and machines, techniques, materials, energy, capital, and time) are used to develop new technologies.* 瞭解：能否趨近及取得工具材料及會不會使用，決定了科技的發展，能展示：如何運用各類資源來發展新科技	**4 3 2 1**

	19	*Technological tools, materials, and other resources should be selected on the basis of safety, cost, availability, appropriateness, and environmental impact; technological processes change energy, information, and material resources into more useful forms.* 瞭解: 當選用科技工具材料等資源時，應考慮安全、成本、是否容易取得、適用性、及對環境的衝擊; 能說明科技的處理過程，能將能源、資訊、及材料改變成爲較有用的形式	**4 3 2 1**
	20	*Understand that tools and machines extend human capabilities, such s holding, lifting, carrying, fastening, separating, and computing.* 瞭解: 工具機械如何的擴展人類的工作能力，譬如握、舉、提、鎖、分離、及計算等	**4 3 2 1**
	21	*Understand that an open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.* 瞭解: 開路系統由於缺乏反饋，所以需要人力來干預才能運作，而閉路系統含有回饋所以可全自動	**4 3 2 1**
Technology and society and human living (social, ethical and human issues) 科技與社會及人類生活	22	*Understand that ethical considerations are important in the development, selection, and use of technologies. Describe personal consequences for the inappropriate or unethical use of technology.* 瞭解: 科技在發展、選擇，及運用時，應如何考量倫理; 瞭解: 個人在使用科技不當時的可能後果	**4 3 2 1**
	23	*Understand that decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.* 瞭解: 如何在使用科技時，考量如何衡量其對環境之利害得失，而做取捨	**4 3 2 1**
	24	*Understand that technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems.* 瞭解: 科技如何用來補救自然災害，以及如何減少廢棄物	**4 3 2 1**
	25	*Knowing that a number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.* 瞭解: 有那些因素會影響--對科技之需求及設計，譬如廣告、經濟景氣、企業目標、和最新的流行等	**4 3 2 1**
	26	*Understand that the transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.* 瞭解: 科技由某社會移到另一社會時，對兩個社會多少都會產生一些文化、社會、經濟、和政治上的影響	**4 3 2 1**
	27	*Knowing that social and cultural priorities and values are reflected in technological devices. In other words, meeting societal expectations is the driving force behind the acceptance and use of products and systems. Understand that the management of waste produced by technological systems is an important societal issue (ITEA, 2000).* 瞭解: 社會和文化所重視的及價值觀，會在科技產品上呈現; 科技產品及系統是否被接納及使用，取決於社會的期待; 對於使用科技而產生廢棄物，如何予以處理，是重要社會議題	**4 3 2 1**

	28	*Able to investigate and assess the influence of a specific technology on the individual, family, community, and environment.* 瞭解: 如何調查評估科技對個人、家庭、社會、和環境的影響	**4 3 2 1**
Impacts and influence of technology 會評估科技產品及科技系統之衝擊	29	*Understand that with the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. The alignment of technological processes with natural processes maximized performance and reduces negative impacts on the environment.* 瞭解: 科技可用來監控環境，以做較佳決策; 如此可使科技之處置與自然界的流程相協調，可得到最佳的效果	**4 3 2 1**
	30	*Describe the important technology inventions that have had significant impacts on human beings. Knowing that the use of inventions and innovations has led to changes in society and the creation of new needs and wants. Explain how technological inventions and innovations have caused global growth and interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete.* 瞭解: 有那些科技的重大發明，曾對人類產生重大衝擊; 瞭解: 創新和改良如何改變社會，並產生新的需求; 瞭解: 科技創新和改良如何導致全世界的成長及互相依賴，並刺激經濟的競爭、創造一些新職業、也淘汰一些過時的職業	**4 3 2 1**
	31	*Knowing that technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences.* 瞭解: 科技本身沒有善惡可言，但是不同的用法，在運用科技產品及系統後，卻會良好或不良的後果	**4 3 2 1**
	32	*Explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.* 瞭解: 在選用科技系統時，爲何要考量一些因素，而做取捨，譬如: 安全、成本、容易操作、售後支援服務、及環境的衝擊等	**4 3 2 1**
	33	*Understand that humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling.* 瞭解:如何運用科技，如 “回收、減量、重複使用等”，來節約能源、用水、及善用土壤	**4 3 2 1**
	34	*Explain that although technological effects are complex and difficult to predict accurately, humans can control the development and implementation of technology (ITEA, 2000).* 瞭解: 人類可以對科技運用的結果做預測，但是因爲較複雜故尚未能準確預測	**4 3 2 1**
	35	*Explains the interrelationships or connections between technologies and describe how technology has affected the environment and society.* 瞭解: 各類科技之間的相互關係，並說明科技對環境及社會的影響	**4 3 2 1**
History and evolution	36	*Students will develop an understanding of the influence of technology on history.* 瞭解: 科技如何影響歷史	**4 3 2 1**

of technology 科技演進史	37	*Gather and organize information to create a database of historical events in technology development. Illustrate how technology has evolved throughout human history.* 能搜集資料以發展一個簡單的資料庫結構來記錄: 人類歷史上科技是如何演進的	**4 3 2 1**
	38	*Knowing that in the past, an invention or innovation was not usually developed with the knowledge of science. In fact, much science knowledge is being gathered alongside the technological development.* 瞭解: 很多科技創新和改良並非依賴科學知識; 事實上，很多科學知識是在科技發展的過程中發現的	**4 3 2 1**
	39	*Knowing that making tools and processing new materials from natural materials advance the technology; besides, putting parts together to create systems and cooperating all specialized skill workers to solve sophisticate problems contribute to the modern technology.* 瞭解: 製造工具及從天然材料中製造出新材料，促進科技的進步; 此外，把各組件結合成一完整的系統以及協調各類技術人力解決複雜問題，促成現代代的科技	**4 3 2 1**
	40	*Knowing that the specialization of function has been at the heart of many technological improvements.* 瞭解: 功能之專業分工如何促成科技的進步	**4 3 2 1**
	41	*Compare qualitatively and quantitatively the performance of a contemporary manufactured product, such as a household appliance, to the comparable device or system 50-100 years ago (ITEA, 2000).* 能做一性能的比較: 以目前的家電設備和 50 到 100 年的同類家用設備做比較，要有量的比較和質的比較	**4 3 2 1**
	42	*Be able to identify trends and monitor potential consequences of technological development.* 瞭解: 科技發展的趨勢並能指出可能的後果	**4 3 2 1**
Agricultural, medical, and bio-technologies **農業醫藥及生化科技**	43	*Knowing that medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. Medical technologies extend the effectiveness of medical care and increase people's wealth.* 瞭解: 醫藥科技包括預防、復健、疫苗、醫藥、醫療及開刀、基因工程，及健康維護系統; 醫藥科技使醫護更爲有效及增進人類福祉	**4 3 2 1**
	44	*Knowing that agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products and in the care of animals.* 瞭解: 農業是指對“食物、纖維、燃料、化學產品等”的生產處理及配銷活動，以及保育各種動物	**4 3 2 1**
	45	*Knowing that conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.* 瞭解: 資源保育包括如防制土壤流失、河道沖蝕、保留水源，改良水質等	**4 3 2 1**

	46	*Knowing that people in unsafe and remote areas can get medical care, such as being diagnosed or getting treatment with telemedicine. Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.* 瞭解: 遠距醫療可使偏遠地區的人受到醫療服務，它是指運用各種較進步的科技，譬如醫藥、電傳、擬真、電腦工程、資訊學、人工智慧、機械人、材料科學、和認知心理學等	**4 3 2 1**
	47	*Knowing that the development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.* 能了解: 冷藏、冷凍、脫水、保存、輻射等科技方法能使食物保鮮而保護人体健康	**4 3 2 1**
	48	*Knowing that biotechnology has application in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. Knowing that the sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures.Therefore, it is necessary to establish ethical mandates for regulating the incidence of testing and the uses of test results.* 瞭解: 生物科技可用於農業、醫療、藥品、食品飲料、能源、環保、和基因工程上; 另瞭解: 生化科學和分子生物科學能用來操縱生物基因，因此應設法管制，以期所做的試驗及其應用都符合倫理	**4 3 2 1**
	49	*Knowing that artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals (ITEA, 2000).* 瞭解: 人工生態系統是人造的環境用來容納人類及動植物生活其間	**4 3 2 1**
Energy and power, transportation technologies 能源動力及運輸科技	50	*Knowing that power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.* 瞭解: 動力是能源換型態的速率，亦即做功的速率	**4 3 2 1**
	51	*Knowing that energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.* 瞭解: 能源的主要型態有熱能、輻射能、電能、機械能、化學能、核能等	**4 3 2 1**
	52	*Knowing that processes, such as receiving, holding, storing, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.* 瞭解: 運輸系統賴“處理/程序”以有效的運作; “處理/程序”包括接收、固持、儲存、搬運、卸載、傳遞、評估、市場行銷、管理、溝通、及遵照規範等	**4 3 2 1**
	53	*Knowing that power systems are used to drive and provide propulsion to other technological products and systems. Power systems must have a source of energy, a process, and loads.* 瞭解: 動力系統是用來驅動其他科技設備或系統; 它包括能源、處理、和負載三部分	**4 3 2 1**

	54	*Knowing that transportation vehicles made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.* 瞭解: 運輸設備由各類子系統協調合作才能良好運作; 這些子系統包括結構系統、推進系統、懸吊系統、導引系統、控制系統、支援系統等	**4**	**3**	**2**	**1**
	55	*Knowing that transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.* 瞭解: 運輸系統對其他科技系統扮演重要角色; 譬如製造、營建、溝通、衛生及安全、及農業等科技	**4**	**3**	**2**	**1**
	56	*Knowing what technologies are using to conserve the natural energy resources, and what approaches can be employed to use energy more efficiently in daily living (ITEA, 2000).* 瞭解: 那些科技可用來保存天然能源，那些方法可用在日常生活中節約能源	**4**	**3**	**2**	**1**
Computer and information technologies 電腦及資訊科技	57	*Knowing that the design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message.* 瞭解: 資訊之建構，主要考慮因素包括--接收的對象、採用之媒体、傳訊目的、及訊息的內容本質	**4**	**3**	**2**	**1**
	58	*Knowing that information and communication systems are made up of a source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. These systems can be used to inform, persuade, entertain, control, manage, and educate.* 瞭解: 資訊與傳播系統的組成部門有: 訊息來源、編碼、傳遞、接收、解碼、儲存、檢索、終點等; 本系統的功用可分為: 通告、解釋、娛樂、控制、管理、和教育	**4**	**3**	**2**	**1**
	59	*Be able to use computers to access and organize information, or use it in various applications. Use technology to locate, evaluate, and collect information from a variety of sources. Use technology tools to process data and report results.* 能使用電腦來處理資料以用在不同用途; 能應用科技來: 找到、評估、及搜集資料; 能使用科技工具來處理資料及呈現結果	**4**	**3**	**2**	**1**
	60	*Use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.* 能採用電傳來與同伴、專家、及其他觀眾，進行協調、互動、及發表	**4**	**3**	**2**	**1**
	61	*Be able to communicate observation, processes, and results of the entire design processes, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.* 能採用語言、文字、圖表、數值、視覺、立体模型等形式來說明: 設計之構想、流程、及結果	**4**	**3**	**2**	**1**
	62	*Use technology tools to enhance learning, increase productivity, and promote creativity.* 能採用科技來輔助學習、增加產能、及增長創造力	**4**	**3**	**2**	**1**
	63	*Use a variety of media and formats to communicate information and ideas effectively to multiple audiences (ITEA, 2000).* 能對不同的聽眾，採用不同的媒体及不同的格式來溝通資訊及發表意見	**4**	**3**	**2**	**1**

Manufacturing and construction technologies 製造及營建科技	64	*Knowing that buildings generally contain a variety of subsystems, such as utilities systems, they are: water, electrical, plumbing, gas, waste disposal, heating and air conditioning, information and communication, as well as component systems, such as foundations, framing, insulation, and lighting.* 能說明建築往往包括很多子系統，譬如給水、供電、管鉗、瓦斯、廢棄物排除、冷暖氣、資訊及傳播、以及建築組件，譬如基礎、結構、隔熱、及照明等	**4 3 2 1**
	65	*Knowing that manufacturing processes include designing products, gathering resources, and using tools to separate, form, combine materials in order to produce products, and servicing of products and systems. Servicing is included because it keeps products in good operating condition.* 能說明製造流程包括: 設計產品、集結資源、採用工具械加工，譬如分解、成形、組合，或修護產品或系統; 其中修護是用來使產品維持在、能良好的運作的狀態	**4 3 2 1**
	66	*Be able to design, fabricate models of construction, and work with other classmates in making a planned model community.* 能和同學一起合作，來設計、製作建築模塊、以完成一個社區模型	**4 3 2 1**
	67	*Knowing that the product design utilizes a broad range of manufacturing processes, such as metal forming, injection molding, rapid tooling, machining, abrasive water jet cutting, and finishing operations.* 能說明產品設計包括廣泛的製造流程: 譬如金屬成形、模具射出成形、快速加工、機械加工、水砂研磨切割、及拋光表面加工	**4 3 2 1**
	68	*Understand that: Structures are constructed using a variety of processes and procedures.　Structures require maintenance, alternation, or renovation periodically to improve them or to alter their intended use.* 瞭解: 結構体是運用一定的程序及方法來完成的; 營建結構需要定期進行: 維護、修改、更新、以滿足或超越原訂的使用目的	**4 3 2 1**
	69	*Be able to follow step-by-step directions to assemble or disassembly a product, observe, and discover how things work.* 能依據說明書的指示來完成組合及分解，以及說明該產品之結構及運作	**4 3 2 1**
	70	*Able to explain how products are manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The cost associated with these functions may introduce yet more constrains on the design (ITEA, 2000).* 能說明產品是如何: 製造、操作、維護、更換、銷毀，以及誰來銷售、操作、及管理或處理它; 並能說明上述各處理之成本，會影響設計時的考量	**4 3 2 1**
Applying the design process and	71	*Understand that design goals and requirements must be established and constraints must be identified and prioritized during the time when designs are being developed. Knowing that the process of engineering design takes into account a number of factors (such as: safety, function, flexibility, quality, and economic, political, and cultural concerns).* 瞭解: 在設計時，"目標"及"要求"要先確訂，"限制"要先確認; 在發展中，限制應列入優先考量; 瞭解: 工程設計應考量下列因素--安全、功能、彈性、品質，以及在經濟、政治、文化上的考量	**4 3 2 1**

s and engineering design 設計的程序	72	*Knowing that the design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.* 瞭解: 結構体的設計及營建,是受到各類相關技術的影響; 譬如 測量技術、控制系統、空間關係的体認等	**4**	**3**	**2**	**1**
	73	*Knowing that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. To be able to express ideas to others verbally and through sketches and models, cause it is an important part of the design process.* 瞭解: 從構想到完成之流程包括: 建立模型、測試、修改; 及能採用文字或圖表模型來表達設計構想	**4**	**3**	**2**	**1**
	74	*Knowing that the design processes include (1) defining a problem, (2), researching and generating ideas by brainstorming, (3) identifying criteria and specifying constraints, (4) exploring possibilities, (5) selecting an approach, (6) developing a design proposal, (7) making a model or prototype, (8) testing and evaluating the design using specifications, refining the design, (10) creating or making it, and (11) communicating processes and results.* 瞭解: 設計的流程包括--釐清問題、以頭腦激盪來產生構想、確認設計之準則及限制、探究可能性、選擇最佳方案、擬訂設計之計劃、製作原型或模型、依據標準來測試及評估、修改設計、製作或實現之、將方法及結果提出報告	**4**	**3**	**2**	**1**
	75	*Knowing that a prototype is a working model used to test a design concept by making actual observations and necessary adjustments (ITEA, 2000).* 瞭解: 原型如何用於測試及修改設計構想	**4**	**3**	**2**	**1**
	76	*Knowing that established design principles should be used to evaluate existing designs, to collect data, and to guide the design process. Be able to evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.* 瞭解: 現有的那些設計原理，可以用在評估設計、搜集資料、及引導設計之進行; 另能採用各類概念的、實体的、及數値的模型，來評估各階段的設計工作，有那些值得改善	**4**	**3**	**2**	**1**
	77	*Knowing that requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.* 瞭解: 所謂“体認”設計的要求，是指 ‘認識”產品系統的性能標準及限制，以及 “了解”這些要求會如何的影響最終的設計發展	**4**	**3**	**2**	**1**

Innovation, problem solving, troubleshooting, R&D, and experimentation 創造發明解決問題及故障排除及實驗	78	*Explain how technological inventions and innovations stimulate economic competitiveness and how, in order for an innovation to lead to commercial success, it must be translated into products and services with marketplace demand. Explain through examples how some inventions are not translated into products and services with market place demand, and therefore do not become commercial successes. Describe the process that an inventor must follow to obtain a patent for an invention.* 瞭解: 科技之創新及改良如何刺激經濟競爭，如何創造出符合市場需求的"產品"及"服務"; 能舉例說明那些產品或服務因爲未能符合市場需求而以失敗收場; 並瞭解: 如何爲新的發明申請專利	**4 3 2 1**
	79	*Be able to use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. Design forecasting techniques to evaluate the results of altering natural systems.* 能採用評量技術，譬如趨勢分析及實驗來推估未來科技的發展; 能設計預測方法來評估當使用科技而改變自然時的後果	**4 3 2 1**
	80	*Knowing that troubleshooting is a problem solving method used to identify the cause of a malfunction in a technological system.* 瞭解: 故障診斷是指對一科技系統之故障，以解決問題的方法，調查其可能的原因	**4 3 2 1**
	81	*Explain and demonstrate several solutions to a problem or opportunity using technological design, tools, careful planning, experimentation, and testing.* 能展示及說明: 如何針對問題或"機會"，採用科技設計、工具、仔細的計劃、進行實驗及測試	**4 3 2 1**
	82	*Knowing that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.* 瞭解: "研究與發展"是工商業運用解決問題的方法，來發展器材或系統滿足市場需求	**4 3 2 1**
	83	*Describes and implements basic troubleshooting techniques for multimedia computer systems with related peripheral devices.* 瞭解: 如何進行多媒体電腦之故障診斷	**4 3 2 1**
	84	*Knowing that troubleshooting is a way of finding out why something does not work so that it can be fixed (ITEA, 2000).* 瞭解: 故障診斷是找出故障原因以便以修復	**4 3 2 1**
To maintain systems and products 系統及產品之維護	85	*Be able to use tools, materials, and machines safely to diagnose, adjust, and repair systems.* 能安全的使用工具、材料、及機械，來診斷、調整、修理系統	**4 3 2 1**
	86	*Be able to troubleshoot, analyze, and maintain system to ensure safe and proper function and precision.* 能診斷、分析、及維護"科技系統"，使其安全、功能正常、及保持精度	**4 3 2 1**
	87	*Demonstrate the ability to select, operate, maintain, troubleshoot, and dispose of technological devices in the context of a career (e.g., use the tools of accounting in a real or simulated business environment.)* 能展示能力: 在某一行職業工作崗位上，能選用、操作、維護、及處理 "科技器材設備"，譬如在實際的、或模擬的、會計工作崗位上，使用有關設備	**4 3 2 1**

	88	*Identify, select, and use appropriate resources to solve problems.* 能確認、選擇、使用適當的資源來解決問題	**4 3 2 1**
	89	*Understand that maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability.* 瞭解: 維護是指定期的檢查及維修產品或系統，使其保持在正常功能、延長使用年限、或提昇其性能	**4 3 2 1**
	90	*Apply technological concepts and processes to solve practical problems and extend human capabilities.* 能應用科技觀念及方法，來解決實際的問題以及延伸人類的工作能力	**4 3 2 1**
	91	*Demonstrate the ability to work safely, efficiently, cooperatively and independently (ITEA, 2000).* 能展示工作能力: 講求工作安全、有效率、能合群、及能獨立 工作	**4 3 2 1**
Accessing, using, and managing the technology 接近使用及管理科技	92	*Be able to use information provided in manuals, protocols, or by experienced people to see and understand how things work.* 能讀懂手冊、型錄、及專家的說明，而了解科技產品的運作	**4 3 2 1**
	93	*Knowing that technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli.* 能說明“科技知識及方法”的各種溝通媒介，包括: 符號、數值、標幟、慣例、螢幕符號、圖表符號、以及輔助視聽及觸覺的語言說明	**4 3 2 1**
	94	*Be able to recognize and use common symbols, such as graphic symbols, signals, and icons, to communicate key ideas.* 能認識及運用常見的符號，譬如圖表符號、標幟、及螢幕符號，來表達主要的構想	**4 3 2 1**
	95	*Describe new management techniques (e.g., computer-aided engineering, computer-integrated manufacturing, total quality management, just-in-time manufacturing), incorporate some of these in a technological endeavor, and explain how they have reduced the length of design-to-manufacture cycles, resulted in more flexible factories, and improved quality and customer satisfaction.* 能說明新的管理技術: 譬如電腦輔助工程、電腦整合製造、全面品質管制、即時製造等是什麼意思; 並能指出當運用它們於一項科技作業時，它們能如何的縮短設計製作流程，而產生更具彈性的工廠、更高品質、及令顧客更滿意	**4 3 2 1**
	96	*Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget. Knowing that quality control is a planned process to ensure that a product, service, or system meets established criteria (ITEA, 2000).* 瞭解: 作業管理是如何的確保科技作業之能獲取利潤、科技產品及系統是如何的品質高、安全、準時製出、且生產成符合預算; 並瞭解: 品質管制是如何的計劃及實施以確保產品及系統符合原訂的標準	**4 3 2 1**
	97	*Help to manage a group engaged in planning, designing, implementation, and evaluation of a project to gain understanding of the management dynamics.* 能展示對管理實務的理解: 譬如幫助一群人進行某一作業之規劃、設計、執行、及評估	**4 3 2 1**

	98	*Be able to select and safely use tools, products, and systems for specific tasks.* 能針對特定用途而慎選、安全的使用、合適的科技產品及系統	**4 3 2 1**
Problem solving, creative, critical, systems and reasoning thinking 解決問題、創作、關鍵思考、系統思考、及理性思考	99	*Be able to brainstorm people's needs and wants and pick some problems that can be solved by technology and through the design process.* 能採用頭腦激盪的方法來列出人類的需求及慾望，並挑出一些問題，嘗試用科技及設計方法來解決	**4 3 2 1**
	100	*Knowing that asking questions and making observations helps a person to figure out how things work. Besides, Knowing that the process of experimentation, which is common in science, can also be used to solve technological problems.* 瞭解: 觀察及提出問題可用來瞭解事務之運作原理; 並瞭解: 科學實驗方法也可用來解決科技問題	**4 3 2 1**
	101	*Be able to explore the emerging technologies and develop the skills to evaluate their impacts by reasoning and making decisions based on asking critical questions.* 能展示: 探究現有的科技，發展評量方法來評量其衝擊，及能提出關鍵的問題以幫助抉擇	**4 3 2 1**
	102	*Be able to test and evaluate the solutions for the design problem in relation to pre-established requirements, and then improve the design solutions or refine the design as needed.* 能展示: 依據預訂要求來評估，所設計的解決問題方法，是否可行，並能做必要的改良	**4 3 2 1**
	103	*Be able to compare, contrast, and classify collected information in order to identify patterns.* 能展示: 如何採用比較、對照、分類等方法來搜集資料，以確認模式	**4 3 2 1**
	104	*Be able to interpret and evaluate the accuracy of the information obtained and determine if it is useful. Be able to synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.* 能展示: 會詮釋及評斷所搜集的資料是否準確，是否有用; 以及會綜合歸納資料、分析趨勢、及做總結來採討科技對個人社會及環境的作用	**4 3 2 1**
	105	*Knowing that systems thinking applies logic and creativity with appropriate compromises in complex real-life problems and involves considering how every part relates to others (ITEA, 2000).* 瞭解: 系統思考是運用邏輯和創造力，並牽就現實情境，從不同角度來衡量問題、並且考量各部門的關係	**4 3 2 1**

[Question #2]: The most appropriate Non-Paper and Pencil Test can be used to assess technological literacy needed by 9th graders in Taiwan

([問題 #2]: 徵詢 那種非紙筆測驗 較適於用來測量各科技能力)

Instruction：
Five most commonly employed non-paper and pencil tests are selected in this study to investigate the opinions of experts in Taiwan. Please check the appropriate tests for each type of the benchmarks, which are listed in the left hand columns of the following table and are affixed with example. More than one test checked is reasonable.
填答方式：
請參攷隨附之各類“非紙筆測驗”評量方法的評量表，以掌握本問卷各評量方法之意涵。
下表左欄是一般科技能力技能指標常呈現的幾種類型； 下表右側各欄則是各類評量方法。
請發表高見--到底各採用那些評量方法爲宜? 煩在適當的空格中打鉤 (可以不只鉤一個)

The Various Performance of Technological Literacy 各類科技能力	**Assessment Methods** 各類評量方法				
	Teacher's Observation 教師觀察	Oral Presentation 口頭報告	**Essay** 書面報告	**Project** 專題製作	**Portfolio** 學習歷程檔案
<Example> To be able to check and send e-mail <舉例]> 會收發電子郵件	√				√

Questions are as follows:

<以上爲舉例，以下爲正式問卷>

The Various Performance of Technological Literacy 各類科技能力	**Assessment Tasks** 各類評量方法				
	Teacher's Observation 教師觀察	Oral Presentation 口頭報告	**Essay** 書面報告	**Project** 專題製作	**Portfolio** 學習歷程檔案
[1] *Technological literacy which are visualized when students showing their understanding of the fundamental concepts of technology and the characteristics of technology.* 科技的知識，科技概念、及對科技的瞭解					
[2] *Technological literacy which are visualized when students are able to investigate, assess, organize, and use information; as well as able to define, identify, defend, justify, support, validate, describe, appraise, explain, illustrate, interpret, analyze, compare, critisize, or evaluate.* 能搜集、整理、判斷、及運用資料；並加以描述、解釋、界訂、論証、分析、比較、對照、評斷、評估、的科技能力					

[3] *Technological literacy which are visualized when students are able to use media, symbols, and formats to communicate observation and ideas.* 會運用符號、媒体等來有效溝通、表達					
[4] *Technological literacy which are visualized when students are able to assemble or disassemble, to use tools, materials, and machines, and to design and fabricate models.* 會設計、製作、拆裝、及使用工具等工作					
[5] *Technological literacy which are visualized when students are able to apply technological concepts and processes, to select, maintain, troubleshoot, and to solve technological problems.* 會應用科技觀念、會選用、維護、故障處置、及解決科技問題					

[Attachment]: Rubrics of six Non-Paper and Pencil Tests selected in this questionnaire

([附件]: 各類非紙筆測驗 之評量表) <以下附件僅供卓參，不必填答也不必寄回>

[名詞定義 1] -- 紙筆測驗評量法(Paper-and-Pencil Test or Multiple-Choice)

是指國內最普遍使用的傳統評量法--選擇題測驗方法。雖然傳統的紙筆測驗(以單選題爲例)會誤導教學(把學生教成只會牢記片斷零碎知識的應試機器)，但並非要完全拋棄，在本研究中，它被拿來當做與各種非傳統評量法的比較基準。

[名詞定義 2] -- 教師觀察評量法(Systematic/Structured Observation)

- 是指教師根據既定的評量表(Rubrics)，針對學生的行爲，衡量其學習成效。評量表之舉例如下: 假設全班 48 人，一表只記載 6 人(則需複製 8 張)。平常情況下，每兩週要系統化觀查全班一遍。若需要觀察學生之工作表現及能力，則可另外於學生進行實習工作及教學活動時，採用此表。

觀察的週次日期: 第__週到第__週，即 (__年_月_日至__年_月_日)	**所觀察的學生姓名**(方格內填入其得分): 5 分(甚優)，4 分(優)，3 分(良)，2 分(可)，1 分(欠佳)					
所顯現的各類行爲之描述	林一	吳二	張三	李四	王五	陳六
上課的態度 (譬如: 不遲到、認真聽講 . . .)						
積極求學的態度 (譬如: 能發問求解 . . .)						
與其他同學協調合作的態度 (譬如: 幫助別人學習 . . .)						
設計的程序方法(譬如: 先多方察考、繪草圖、做計劃、做記錄、 . . .)						
解決科技問題的程序方法(譬如: 先認清問題、多方尋求解答、測試各解法、 . . .)						
製作及工作的方法及能力 (譬如: 能採用正確的工作方法 . . .)						
能表現出良好的工作習慣 (譬如: 安全、衛生、有效率、愛惜公物、整潔、 . . .)						
具團隊合作能力 (譬如: 能溝通、能積極參與、能有效做好分內工作、能尊重隊友、能重視團隊榮譽、 . . .)						
. . . 其他行爲的描述 . . .						

得分小計:						

- 本表及下列各評量表僅用來描述: 如何較客觀評量，並不代表是最好的評量表; 理想的評量表，仍有待我們全体合力來發展。

[名詞定義 3] -- 口頭報告評量法 (Oral Presentation)

是指教師根據既定的評量表(Rubrics)，來針對學生的口頭報告，來衡量其學習成效。適用於當學習某一單元告一段落或完成某一項作業時，由學生提出口頭報告。對大批學生施測時，也可先錄成錄影帶供不同的評審來評。

評量的日期、節次: **(__年_月_日第__節)**	**所觀察的學生姓名(方格內填入其得分):** **5 分(甚優)，4 分(優)，3 分(良)，2 分(可)，1 分(欠佳)**					
各類實質學習成效之描述	林一	吳二	張三	李四	王五	陳六
對主題有透澈的理解(譬如: 能用自己的話來做一全面介紹 . . .)						
能迎合觀眾需求 (譬如: 能吸引觀眾、打動之、引起共鳴、 . . .)						
講述內容有組織 (譬如: 前後連貫 . . .)						
能掌握重點無贅言 (譬如: 能分段 . . .)						
能有引言及結論 (譬如: 能做總結 . . .)						
講解生動而熱誠 (譬如: 能有面部表情及手勢 . . .)						
能解說學習方法及心得 (譬如: 如何界定題目、找解答、工作歷程及檢討等 . .)						
能充分準備 (譬如: 顯示因預習而熟練 . .)						
能運用各類視聽媒体或圖表 (譬如: 掛圖或透明片 . . .)						
演說技巧 (譬如: 腔調、停頓、目視聽眾 . .)						
. . . 其他行爲的描述 . . .						
得分小計:						

[名詞定義 4] -- 文字報告評量法 (Essay Test)

是指教師根據既定的評量表(Rubrics)，來針對學生的書面報告，來衡量其學習成效。適用於當學習某一單元告一段落時，或依照教師指定題目，完成某項研究時，由學生提出書面報告。

評量的日期、節次: (__年_月_日第__節)	**所觀察的學生姓名**(方格內填入其得分): 5 分(甚優)，4 分(優)，3 分(良)，2 分(可)，1 分(欠佳)					
各類實質學習成效之描述	林一	吳二	張三	李四	王五	陳六
對主題的深入了解 (譬如: 能用自己的話來做一精要的介紹 . . .)						
對相關問題的廣泛了解 (譬如: 全面了解問題背景、現況、意義、相關議題等 . . .)						
內容豐富包括了全面而精確的知識 (譬如: 資料新穎、翔實、精確、 . . .)						
描述清晰生動 (譬如: 能舉例闡釋 . . .)						
能整理出特點而呈現特色 (譬如: 能說明各特點之意義 . . .)						

能客觀具体的評論(譬如: 能分析出優缺點及提出改良建議 . . .)						
文章結構堅實無贅言(譬如: 各段落能前後呼應 . . .)						
得分小計:						

[名詞定義 5] -- 專題製作評量法 (Projects)

是指教師根據既定的評量表(Rubrics)，來針對學生的作品，來衡量其學習成效。適用於學生依照教師指定題目，完成某項專題製作時，由學生提出作品及相關資料記錄。

評量的日期、節次: (__年_月_日第__節)	所觀察的學生姓名(方格內填入其得分): 5 分(甚優)，4 分(優)，3 分(良)，2 分(可)，1 分(欠佳)					
所顯現的各類能力之描述	林一	吳二	張三	李四	王五	陳六
能廣泛的蒐集最新資料以充分了解問題背景及釐清問題確立目標 (譬如: 上網、查參考書、市場調查、 . .)						
能預擬設計製作之工作計劃，並做好實習工場器材工具之準備 (譬如: 擬好工作步驟及繪出草圖， . . .)						
能做好工作記錄並能隨時據以簡報 (譬如: 詳述工作方法進度困難及心得 . . .)						
能明智的聯想 (譬如: 能探索所學所做的和其他學科的關係、和過去所學的關係、和相關研究製作之關係、其意義所在、其作用影響、以及和科技、社會、及倫理規範的關係 . . .)						
能完成有創造性的設計 (譬如: 能打破傳統，創作、改良、解決科技問題 . . .)						
能完成品質佳的製作(譬如: 能有效運用有限資源，經濟的製出: 符合目標要求的作品 . . .)						
得分小計:						

[名詞定義 6] -- 學習檔案評量法 (Portfolios)

是指教師根據既定的評量表(Rubrics)，來針對學生的學習成就檔案，來衡量其學習成效。適用於學期結束時，按照原訂之格式，由學生將全學期學習成就之相關資料整理成彙編，提供評審。

評量的日期、節次: (__年_月_日第__節)	所觀察的學生姓名(方格內填入其得分): 5 分(甚優)，4 分(優)，3 分(良)，2 分(可)，1 分(欠佳)					
顯現的各類能力表現之描述	林一	吳二	張三	李四	王五	陳六
能符合繳交之期限規定 (譬如: 在製作過程就能符合進度、並如期完成繳交 . . .)						
能符合規定格式 (譬如: 包括有封面、目次、摘要、繳交作業之記錄、指定的其他作業、設計之作品，設計之網頁記述、工作記錄、照片、錄影帶、同儕之評語等 . . .)						
能自我省視檢討能力之增長 (譬如: 能自我檢討而列出各類學習成效、各類能力之成長、 . . .)						
能展示學習的深度及廣度 (譬如: 能分析及用實証來顯示: 對學習目標內容之全盤了解 . . .)						

內容豐富 (譬如:包括詳細的學習歷程資料，如事先計劃，過程中的作業，修改的作業及最後的成品等 . .)						
展現出創意 (譬如: 展現創新及改良、沒有抄襲或改寫別人文章、沿用別人方法的現象、 . . .)						
編輯製作品質佳 (譬如: 組織良好、編輯用心仔細、整体觀感優良、 . . .)						
語言文字技巧佳 (譬如: 無錯別字、用詞簡潔、語意清晰、 . . .)						
得分小計:						

APPENDIX I

QUESTIONNAIRE FOR SECOND-ROUND OF DELPHI STUDY

Appendix I Questionnaire for second-round of Delphi study

Dear Panel Member,

Thank you for filling the first round Panel questionnaire.
In this second round Panel questionnaire we show the results of the first round Panel questionnaire.Please take them for your referencese.In this Panel questionnaire, wewill be asking you, what you think of the most important benchmarks of technological literacy of 9th graders in Taiwan. We will also be seeking your opinions on the most appropriate assessment methods to evaluate their technological literacy other than paper and pencil test.

親愛的科技教育專家：

感謝您於首輪問卷中惠賜您的寶貴意見。首輪問卷結果經統計處理後，茲將各專家對各項目意見之平均數及變異數列於題目最右欄。敬請您參考首輪問卷結果後，重新於每一項目之「重要性」一欄填答。本問卷擬就國中三年級學生應該具備何種科技能力，以及那些非傳統紙筆測驗方法、較值得採行等項目進行討論，請惠予以表示高見。

[Question #1]: The Benchmarks of technological literacy needed by 9th graders in Taiwan

([問題 #1]: 徵詢 國中三年級學生 科技能力之重要指標)

Instruction：
Please select the importance of following potential benchmarks according to the scale -
- *4 if you felt this is a very important benchmark of technological literacy*
- *3 if you felt this is an above average importance benchmark of technological literacy*
- *2 if you felt this is a below average importance benchmark of technological literacy*
- *1 if you felt this is a very unimportant benchmark of technological literacy*

表達方式：
請最左側空格裏**<4,3,2,1>**四個數字間選擇一個數字加以圈選，來表達您對下列各技能指標重要性的看法：
<4>代表最重要，**<3>**代表還算重要，**<2>**代表不太重要，**<1>**代表最不重要

Category	# N	**Benchmarks** 技能指標	首輪問卷結果		**Importance** 重要性
			M 平均數	**SD** 標準差	
		<Example>： *To be able to go to library and to write a summary of what he/she found.* <舉例>： **(**會：上圖書館查資料、並寫出心得摘要**)**			<Example> **4 3 2 1**

Questions are in the next page:

<以上爲舉例，以下爲正式問卷>

Category 指標類別	Item # 編號	Benchmarks 技能指標	首輪問卷結果		Importance 重要性
			M 平均數	SD 標準差	
The characteristics and scope of technology 科技的範圍及特性	1	*Justify the study of technology uses many of the same ideas and skills as other subjects; and the knowledge gained from other fields of study has a direct effect on the development of technological products and systems; Defend that technologies are often combined. Various relationships exist between technology and other fields of study.* 能說明科技的發展與其他學科密切相關，皆是採用類似的方法來發展的，且各類科技之間也是息息相關	3.083	0.776	**4 3 2 1**
	4	*Support that Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function.* 能說明所謂科技之轉移,是把現有的科技方法或發明，運用於新的用途	3.208	0.721	**4 3 2 1**
	5	*Validate that technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields.* 能說明所謂科技創新往往發生於:把構想和技術,從某一類科技運用於另一類科技	3.083	0.881	**4 3 2 1**

Tools, resources, systems, technological processes,	13	*Knowing that throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies.* 瞭解: 綜觀歷史，科技都是導因於社會、工業、商業、及個人之需求、價值觀、及利益發生了改變	3.125	0.68	**4 3 2 1**

and relationships 工具資源系統及科技程序之關係	14	*Knowing that the development and use of technology influence economic, political, social, cultural, and ethical issues . (ITEA, 2000).* 瞭解：科技之發展運用，對文化、社會、經濟、政治、及倫理之影響	3.25	0.608	**4 3 2 1**

Technological processes, and System 科技系統及科技程序	16	*Able to explain how complex technological systems involve the confluence of numerous other systems. Explain how the submarine or airplanes involves communication, transportation, bio-technology, and manufacturing systems (ITEA, 2000).* 瞭解：科技系統是由各類子系統匯集而成，並能舉例說明潛水艇和飛機如何包括通訊、運輸、生物科技、製造等系統	3.167	0.637	**4 3 2 1**
	18	*Understand that access to and ability to use tools, materials, and skills limits technological development. Demonstrate the ways that multiple resources (such as people, information, tools and machines, techniques, materials, energy, capital, and time) are used to develop new technologies.* 瞭解：能否趨近及取得工具材料及會不會使用，決定了科技的發展，能展示：如何運用各類資源來發展新科技	3.042	0.806	**4 3 2 1**
	20	*Understand that tools and machines extend human capabilities, such s holding, lifting, carrying, fastening, separating, and computing.* 瞭解：工具機械如何的擴展人類的工作能力，譬如握、舉、提、鎖、分離、及計算等	2.917	0.974	**4 3 2 1**
	21	*Understand that an open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.* 瞭解：開路系統由於缺乏反饋，所以需要人力來干預才能運作，而閉路系統含有回饋所以可全自動	2.25	0.897	**4 3 2 1**

Technology and Society 科技與社會	25	*Knowing that a number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.* 瞭解: 有那些因素會影響—對科技之需求及設計，譬如廣告、經濟景氣、企業目標、和最新的流行等	2.625	0.824	**4 3 2 1**
	26	*Understand that the transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.* 瞭解: 科技由某社會移到另一社會時，對兩個社會多少都會產生一些文化、社會、經濟、和政治上的影響	2.667	0.868	**4 3 2 1**
	27	*Knowing that social and cultural priorities and values are reflected in technological devices. In other words, meeting societal expectations is the driving force behind the acceptance and use of products and systems. Understand that the management of waste produced by technological systems is an important societal issue (ITEA, 2000).* 瞭解: 社會和文化所重視的及價值觀，會在科技產品上呈現; 科技產品及系統是否被接納及使用，取決於社會的期待; 對於使用科技而產生廢棄物，如何予以處理，是重要社會議題	3.25	0.847	**4 3 2 1**
	28	*Able to investigate and assess the influence of a specific technology on the individual, family, community, and environment.* 瞭解: 如何調查評估科技對個人、家庭、社會、和環境的影響	3.25	0.608	**4 3 2 1**

Impacts and influence of technology 會評估科技產品及科技系統之衝擊	29	*Understand that with the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. The alignment of technological processes with natural processes maximized performance and reduces negative impacts on the environment.* 瞭解: 科技可用來監控環境,以做較佳決策; 如此可使科技之處置與自然界的流程相協調，可得到最佳的效果	2.792	0.884	**4 3 2 1**

Impacts and influence of technology 會評估科技產品及科技系統之衝擊	30	*Describe the important technology inventions that have had significant impacts on human beings. Knowing that the use of inventions and innovations has led to changes in society and the creation of new needs and wants. Explain how technological inventions and innovations have caused global growth and interdependence, stimulated economic competitiveness, created new jobs, and made other jobs obsolete.* 瞭解: 有那些科技的重大發明，曾對人類產生重大衝擊; 瞭解: 創新和改良如何改變社會,並產生新的需求; 瞭解: 科技創新和改良如何導致全世界的成長及互相依賴，並刺激經濟的競爭、創造一些新職業、也淘汰一些過時的職業	3.333	0.816	**4 3 2 1**
	32	*Explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.* 瞭解: 在選用科技系統時，為何要考量一些因素，而做取捨，譬如: 安全、成本、容易操作、售後支援服務、及環境的衝擊等	3.25	0.676	**4 3 2 1**
	34	*Explain that although technological effects are complex and difficult to predict accurately, humans can control the development and implementation of technology.* 瞭解: 人類可以對科技運用的結果做預測，但是因為較複雜故尚未能準確預測	2.708	0.859	**4 3 2 1**

History and evolution of technology 科技演進史	36	*Students will develop an understanding of the influence of technology on history.* 瞭解: 科技如何影響歷史	2.917	0.881	**4 3 2 1**
	38	*Knowing that in the past, an invention or innovation was not usually developed with the knowledge of science. In fact, much science knowledge is being gathered alongside the technological development.* 瞭解: 很多科技創新和改良並非依賴科學知識; 事實上，很多科學知識是在科技發展的過程中發現的	3.208	0.932	**4 3 2 1**

	39	*Knowing that making tools and processing new materials from natural materials advance the technology; besides, putting parts together to create systems and cooperating all specialized skill workers to solve sophisticate problems contribute to the modern technology.* 瞭解: 製造工具及從天然材料中製造出新材料，促進科技的進步; 此外，把各組件結合成一完整的系統以及協調各類技術人力解決複雜問題，促成現代化的科技	2.792	0.977	**4 3 2 1**
	40	*Knowing that the specialization of function has been at the heart of many technological improvements.* 瞭解: 功能之專業分工如何促成科技的進步	2.583	0.881	**4 3 2 1**
	41	*Compare qualitatively and quantitatively the performance of a contemporary manufactured product, such as a household appliance, to the comparable device or system 50-100 years ago (ITEA, 2000).* 能做一性能的比較: 以目前的家電設備和 50 到 100 年的同類家用設備做比較，要有量的比較和質的比較	2.917	0.881	**4 3 2 1**
	42	*Be able to identify trends and monitor potential consequences of technological development.* 瞭解: 科技發展的趨勢並能指出可能的後果	3.167	0.702	**4 3 2 1**

Agricultural, medical, and bio-technologies **農業醫藥及生化科技**	43	*Knowing that medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. Medical technologies extend the effectiveness of medical care and increase people' s wealth.* 瞭解: 醫藥科技包括預防、復健、疫苗、醫藥、醫療及開刀、基因工程，及健康維護系統; 醫藥科技使醫護更為有效及增進人類福祉	2.708	0.806	**4 3 2 1**
	44	*Knowing that agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products and in the care of animals.* 瞭解: 農業是指對“ 食物、纖維、燃料、化學產品等”的生產處理及配銷活動，以及保育各種動物	2.5	0.78	**4 3 2 1**

	45	*Knowing that conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.* 瞭解: 資源保育包括如防制土壤流失、河道沖蝕、保留水源，改良水質等	3.042	0.751	**4 3 2 1**
	46	*Knowing that people in unsafe and remote areas can get medical care, such as being diagnosed or getting treatment with telemedicine. Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.* 瞭解: 遠距醫療可使偏遠地區的人受到醫療服務，它是指運用各種較進步的科技，譬如醫藥、電傳、擬真、電腦工程、資訊學、人工智慧、機械人、材料科學、和認知心理學等	2.75	0.944	**4 3 2 1**
	47	*Knowing that the development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.* 能了解: 冷藏、冷凍、脫水、保存、輻射等科技方法能使食物保鮮而保護人体健康	2.833	0.868	**4 3 2 1**
	49	*Knowing that artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals (ITEA, 2000).* 瞭解: 人工生態系統是人造的環境用來容納人類及動植物生活其間	2.208	0.884	**4 3 2 1**

Energy and power, transportation technologies 能源動力及運輸科技	50	*Knowing that power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.* 瞭解: 動力是能源換型態的速率，亦即做功的速率	2.875	0.85	**4 3 2 1**
	51	*Knowing that energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.* 瞭解: 能源的主要型態有熱能、輻射能、電能、機械能、化學能、核能等	3.292	0.806	**4 3 2 1**

技	52	*Knowing that processes, such as receiving, holding, storing, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.* 瞭解: 運輸系統賴“ 處理/程序” 以有效的運作; “ 處理/程序” 包括接收、固持、儲存、搬運、卸載、傳遞、評估、市場行銷、管理、溝通、及遵照規範等	2.917	0.83	**4 3 2 1**
	54	*Knowing that transportation vehicles made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively.* 瞭解: 運輸設備由各類子系統協調合作才能良好運作; 這些子系統包括結構系統、推進系統、懸吊系統、導引系統、控制系統、支援系統等	3.083	0.776	**4 3 2 1**
	55	*Knowing that transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.* 瞭解: 運輸系統對其他科技系統扮演重要角色; 譬如製造、營建、溝通、衛生及安全、及農業等科技	2.958	0.69	**4 3 2 1**

Computer and information technologies 電腦及資訊科技	58	*Knowing that information and communication systems are made up of a source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. These systems can be used to inform, persuade, entertain, control, manage, and educate.* 瞭解: 資訊與傳播系統的組成部門有: 訊息來源、編碼、傳遞、接收、解碼、儲存、檢索、終點等; 本系統的功用可分為: 通告、解釋、娛樂、控制、管理、和教育	3	0.885	**4 3 2 1**
	63	*Use a variety of media and formats to communicate information and ideas effectively to multiple audiences (ITEA, 2000).* 能對不同的聽眾，採用不同的媒体及不同的格式來溝通資訊及發表意見	3.25	0.794	**4 3 2 1**

	65	*Knowing that manufacturing processes include designing products, gathering resources, and using tools to separate, form, combine materials in order to produce products, and servicing of products and systems. Servicing is included because it keeps products in good operating condition.* 能說明製造流程包括: 設計產品、集結資源、採用工具械加工，譬如分解、成形、組合，或修護產品或系統; 其中修護是用來使產品維持在、能良好的運作的狀態	3.167	0.761	**4 3 2 1**
	66	*Be able to design, fabricate models of construction, and work with other classmates in making a planned model community.* 能和同學一起合作，來設計、製作建築模塊、以完成一個社區模型	3.125	0.68	**4 3 2 1**
	67	*Knowing that the product design utilizes a broad range of manufacturing processes, such as metal forming, injection molding, rapid tooling, machining, abrasive water jet cutting, and finishing operations.* 能說明產品設計包括廣泛的製造流程: 譬如金屬成形、模具射出成形、快速加工、機械加工、水砂研磨切割、及拋光表面加工	2.75	0.944	**4 3 2 1**
	68	*Understand that: Structures are constructed using a variety of processes and procedures. Structures require maintenance, alternation, or renovation periodically to improve them or to alter their intended use.* 瞭解: 結構体是運用一定的程序及方法來完成的; 營建結構需要定期進行: 維護、修改、更新、以滿足或超越原訂的使用目的	2.917	0.717	**4 3 2 1**
	70	*Able to explain how products are manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The cost associated with these functions may introduce yet more constrains on the design (ITEA, 2000).* 能說明產品是如何: 製造、操作、維護、更換、銷毀，以及誰來銷售、操作、及管理或處理它; 並能說明上述各處理之成本，會影響設計時的考量	3.083	0.776	**4 3 2 1**

Applying the design process and engineering design **設計的程序**	71	*Understand that design goals and requirements must be established and constraints must be identified and prioritized during the time when designs are being developed. Knowing that the process of engineering design takes into account a number of factors (such as: safety, function, flexibility, quality, and economic, political, and cultural concerns).* 瞭解: 在設計時,“ 目標” 及“ 要求” 要先確訂,“ 限制” 要先確認; 在發展中，限制應列入優先考量; 瞭解: 工程設計應考量下列因素—安全、功能、彈性、品質，以及在經濟、政治、文化上的考量	3.208	0.779	**4 3 2 1**
	72	*Knowing that the design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships.* 瞭解: 結構体的設計及營建，是受到各類相關技術的影響; 譬如 測量技術、控制系統、空間關係的体認等	2.542	0.833	**4 3 2 1**
	75	*Knowing that a prototype is a working model used to test a design concept by making actual observations and necessary adjustments (ITEA, 2000).* 瞭解: 原型如何用於測試及修改設計構想	3.174	0.778	**4 3 2 1**

Innovation, problem solving, troubleshooting, R&D, and experimentation 創造發明解決問題及故障排除及實驗	78	*Explain how technological inventions and innovations stimulate economic competitiveness and how, in order for an innovation to lead to commercial success, it must be translated into products and services with marketplace demand. Explain through examples how some inventions are not translated into products and services with market place demand, and therefore do not become commercial successes. Describe the process that an inventor must follow to obtain a patent for an invention.* 瞭解: 科技之創新及改良如何刺激經濟競爭，如何創造出符合市場需求的“ 產品” 及“ 服務”; 能舉例說明那些產品或服務因為未能符合市場需求而以失敗收場; 並瞭解: 如何為新的發明申請專利	2.739	0.864	**4 3 2 1**
	79	*Be able to use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. Design forecasting techniques to evaluate the results of altering natural systems.* 能採用評量技術，譬如趨勢分析及實驗來推估未來科技的發展; 能設計預測方法來評估當使用科技而改變自然時的後果	2.304	0.822	**4 3 2 1**

驗	80	*Knowing that troubleshooting is a problem solving method used to identify the cause of a malfunction in a technological system.* 瞭解: 故障診斷是指對一科技系統之故障，以解決問題的方法，調查其可能的原因	3.043	0.706	**4 3 2 1**
	81	*Explain and demonstrate several solutions to a problem or opportunity using technological design, tools, careful planning, experimentation, and testing.* 能展示及說明: 如何針對問題或" 機會" ，採用科技設計、工具、仔細的計劃、進行實驗及測試	3.087	0.596	**4 3 2 1**
	82	*Knowing that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.* 瞭解: " 研究與發展" 是工商業運用解決問題的方法，來發展器材或系統滿足市場需求	3.13	0.869	**4 3 2 1**
	83	*Describes and implements basic troubleshooting techniques for multimedia computer systems with related peripheral devices.* 瞭解: 如何進行多媒体電腦之故障診斷	2.87	0.869	**4 3 2 1**
	84	*Knowing that troubleshooting is a way of finding out why something does not work so that it can be fixed (ITEA, 2000).* 瞭解: 故障診斷是找出故障原因以便以修復	2.87	0.815	**4 3 2 1**

To maintain systems and products 系統及產品之維護	87	*Demonstrate the ability to select, operate, maintain, troubleshoot, and dispose of technological devices in the context of a career (e.g., use the tools of accounting in a real or simulated business environment.)* 能展示能力: 在某一行職業工作崗位上，能選用、操作、維護、及處理" 科技器材設備" ，譬如在實際的、或模擬的、會計工作崗位上，使用有關設備	2.478	0.898	**4 3 2 1**

Accessing, using, and managing the technology 接近使用及管理科技	95	*Describe new management techniques (e.g., computer-aided engineering, computer-integrated manufacturing, total quality management, just-in-time manufacturing), incorporate some of these in a technological endeavor, and explain how they have reduced the length of design-to-manufacture cycles, resulted in more flexible factories, and improved quality and customer satisfaction.* 能說明新的管理技術: 譬如電腦輔助工程、電腦整合製造、全面品質管制、即時製造等是什麼意思; 並能指出當運用它們於一項科技作業時，它們能如何的縮短設計製作流程，而產生更具彈性的工廠、更高品質、及令顧客更滿意	2.565	0.896	**4 3 2 1**
	96	*Project management is essential to ensuring that technological endeavors are profitable and that products and systems are of high quality and built safely, on schedule, and within budget. Knowing that quality control is a planned process to ensure that a product, service, or system meets established criteria (ITEA, 2000).* 瞭解: 作業管理是如何的確保科技作業之能獲取利潤、科技產品及系統是如何的品質高、安全、準時製出、且生產成符合預算; 並瞭解: 品質管制是如何的計劃及實施以確保產品及系統符合原訂的標準	2.565	0.945	**4 3 2 1**
	97	*Help to manage a group engaged in planning, designing, implementation, and evaluation of a project to gain understanding of the management dynamics.* 能展示對管理實務的理解: 譬如幫助一群人進行某一作業之規劃、設計、執行、及評估	2.391	0.891	**4 3 2 1**

Problem solving, creative, critical, systems and reasoning thinking 解決問	100	*Knowing that asking questions and making observations helps a person to figure out how things work. Besides, Knowing that the process of experimentation, which is common in science, can also be used to solve technological problems.* 瞭解: 觀察及提出問題可用來瞭解事務之運作原理; 並瞭解: 科學實驗方法也可用來解決科技問題	3.25	0.737	**4 3 2 1**

題、創作、關鍵思考、系統思考、及理性思考	101	*Be able to explore the emerging technologies and develop the skills to evaluate their impacts by reasoning and making decisions based on asking critical questions.* 能展示: 探究現有的科技，發展評量方法來評量其衝擊，及能提出關鍵的問題以幫助抉擇	2.75	0.794	**4 3 2 1**
	102	*Be able to test and evaluate the solutions for the design problem in relation to pre-established requirements, and then improve the design solutions or refine the design as needed.* 能展示: 依據預訂要求來評估，所設計的解決問題方法，是否可行，並能做必要的改良	3.25	0.737	**4 3 2 1**
	103	*Be able to compare, contrast, and classify collected information in order to identify patterns.* 能展示: 如何採用比較、對照、分類等方法來搜集資料，以確認模式	3.083	0.654	**4 3 2 1**
	104	*Be able to interpret and evaluate the accuracy of the information obtained and determine if it is useful. Be able to synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.* 能展示: 會詮釋及評斷所搜集的資料是否準確，是否有用; 以及會綜合歸納資料、分析趨勢、及做總結來採討科技對個人社會及環境的作用	3	0.722	**4 3 2 1**
	105	*Knowing that systems thinking applies logic and creativity with appropriate compromises in complex real-life problems and involves considering how every part relates to others (ITEA, 2000).* 瞭解: 系統思考是運用邏輯和創造力，並牽就現實情境，從不同角度來衡量問題、並且考量各部門的關係	2.667	0.917	**4 3 2 1**

[Question #2]: The most appropriate Non-Paper and Pencil Test can be used to assess technological literacy needed by 9th graders in Taiwan

([問題 #2]: 徵詢 那種非紙筆測驗 較適於用來測量各科技能力**)**

Instruction：

Five most commonly employed non-paper and pencil tests are selected in this study to investigate the opinions of experts in Taiwan. Please check the appropriate tests for each type of the benchmarks, which are listed in the left hand columns of the following table and are affixed with example. More than one test checked is reasonable.

填答方式：

請參玫隨附之各類“非紙筆測驗”評量方法的評量表，以掌握本問卷各評量方法之意涵。

下表左欄是一般科技能力技能指標常呈現的幾種類型；　下表右側各欄則是各類評量方法。

請發表高見**--**到底各採用那些評量方法爲宜**?** 煩在適當的空格中打鉤 **(**可以不只鉤一個**)**

The Various Performance of Technological Literacy 各類科技能力	**Assessment Methods** 各類評量方法				
	Teacher's Observation 教師觀察	Oral Presentation 口頭報告	**Essay** 書面報告	**Project** 專題製作	**Portfolio** 學習歷程檔案
<Example> To be able to check and send e-mail <舉例]> 會收發電子郵件	√				√

<以上爲舉例，以下爲正式問卷>

The Various Performance of Technological Literacy 各類科技能力	**Assessment Tasks** 各類評量方法				
	Teacher's Observation 教師觀察	Oral Presentation 口頭報告	**Essay** 書面報告	**Project** 專題製作	**Portfolio** 學習歷程檔案
[1] *Technological literacy which are visualized when students showing their understanding of the fundamental concepts of technology and the characteristics of technology.* 科技的知識，科技概念、及對科技的瞭解					
[2] *Technological literacy which are visualized when students are able to investigate, assess, organize, and use information; as well as able to define, identify, defend, justify, support, validate, describe, appraise, explain, illustrate, interpret, analyze, compare, critisize, or evaluate.* 能搜集、整理、判斷、及運用資料；並加以描述、解釋、界訂、論証、分析、比較、對照、評斷、評估、的科技能力					

[3] *Technological literacy which are visualized when students are able to use media, symbols, and formats to communicate observation and ideas.* 會運用符號、媒体等來有效溝通、表達					
[4] *Technological literacy which are visualized when students are able to assemble or disassemble, to use tools, materials, and machines, and to design and fabricate models.* 會設計、製作、拆裝、及使用工具等工作					
[5] *Technological literacy which are visualized when students are able to apply technological concepts and processes, to select, maintain, troubleshoot, and to solve technological problems.* 會應用科技觀念、會選用、維護、故障處置、及解決科技問題					

APPENDIX J

QUESTIONNAIRE FOR THIRD-ROUND OF DELPHI STUDY

<u>Appendix J Questionnaire for third-round of Delphi study</u>

Dear Panel Member,

Thank you for filling the second round Panel questionnaire.
In this second round Panel questionnaire we show the results of the first round Panel questionnaire.Please take them for your referencese.In this Panel questionnaire, wewill be asking you, what you think of the most important benchmarks of technological literacy of 9th graders in Taiwan. We will also be seeking your opinions on the most appropriate assessment methods to evaluate their technological literacy other than paper and pencil test.

親愛的科技教育專家：

感謝您於第二輪問卷中惠賜您的寶貴意見。第二輪問卷結果經統計處理後，茲將各專家對各項目意見之平均數及變異數列於題目最右欄。敬請您參考第二輪問卷結果後，重新於每一項目之「重要性」一欄填答。
本問卷擬就國中三年級學生應該具備何種科技能力，以及那些非傳統紙筆測驗方法、較值得採行等項目進行討論，請惠予以表示高見，並請您於 **5/8(**四**)**前擲回，感謝您的參與！

<u>[Question #1]: The Benchmarks of technological literacy needed by 9th graders in Taiwan</u>
([問題 #1]: 徵詢 國中三年級學生 科技能力之重要指標**)**

***Instruction*：**
Please select the importance of following potential benchmarks according to the scale -
- *4* *if you felt this is a very important benchmark of technological literacy*
- *3* *if you felt this is an above average importance benchmark of technological literacy*
- *2* *if you felt this is a below average importance benchmark of technological literacy*
- *1* *if you felt this is a very unimportant benchmark of technological literacy*

表達方式：
請最左側空格裏**<4,3,2,1>**四個數字間選擇一個數字加以圈選，來表達您對下列各技能指標重要性的看法：
<4>代表最重要，**<3>**代表還算重要，**<2>**代表不太重要，**<1>**代表最不重要

Category	# N	**<u>Benchmarks</u>** 技能指標	首輪問卷結果		**Importance** 重要性
			<u>M</u> 平均數	**<u>SD</u>** 標準差	

		<Example>： *To be able to go to library and to write a summary of what he/she found.* <舉例>： **(會：上圖書館查資料、並寫出心得摘要)**			<Example> **4 3 2 1**

Questions are in next page:

<以上為舉例，以下為正式問卷>

Category 指標類別	**Item #** 編號	**Benchmarks** 技能指標	首輪問卷結果		**Importance** 重要性
			M 平均數	**SD** 標準差	
Technological processes, and System 科技系統及科技程序	18	*Understand that access to and ability to use tools, materials, and skills limits technological development. Demonstrate the ways that multiple resources (such as people, information, tools and machines, techniques, materials, energy, capital, and time) are used to develop new technologies.* **瞭解：能否趨近及取得工具材料及會不會使用，決定了科技的發展，能展示：如何運用各類資源來發展新科技**	3.042	0.806	**4 3 2 1**
	20	*Understand that tools and machines extend human capabilities, such s holding, lifting, carrying, fastening, separating, and computing.* **瞭解：工具機械如何的擴展人類的工作能力，譬如握、舉、提、鎖、分離、及計算等**	2.917	0.974	**4 3 2 1**
	21	*Understand that an open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.* **瞭解：開路系統由於缺乏反饋，所以需要人力來干預才能運作，而閉路系統含有回饋所以可全自動**	2.25	0.897	**4 3 2 1**

Technology and Society 科技與社	25	*Knowing that a number of different factors, such as advertising, the strength of the economy, the goals of a company, and the latest fads contribute to shaping the design of and demand for various technologies.* **瞭解：有那些因素會影響—對科技之需求及設計，譬如廣告、經濟景氣、企業目標、和最新的流行等**	2.625	0.824	**4 3 2 1**

與社會	26	*Understand that the transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees.* 瞭解: 科技由某社會移到另一社會時，對兩個社會多少都會產生一些文化、社會、經濟、和政治上的影響	2.667	0.868	**4 3 2 1**

Impacts and influence of technology 會評估科技產品及科技系統之衝擊	29	*Understand that with the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. The alignment of technological processes with natural processes maximized performance and reduces negative impacts on the environment.* 瞭解: 科技可用來監控環境，以做較佳決策; 如此可使科技之處置與自然界的流程相協調，可得到最佳的效果	2.792	0.884	**4 3 2 1**
	32	*Explain why making tradeoffs among characteristics, such as safety, function, cost, ease of operation, quality of post-purchase support, and environmental impact, is necessary when selecting systems for specific purposes.* 瞭解: 在選用科技系統時，為何要考量一些因素，而做取捨，譬如: 安全、成本、容易操作、售後支援服務、及環境的衝擊等	3.25	0.676	**4 3 2 1**
	34	*Explain that although technological effects are complex and difficult to predict accurately, humans can control the development and implementation of technology (ITEA, 2000).* 瞭解: 人類可以對科技運用的結果做預測，但是因為較複雜故尚未能準確預測	2.708	0.859	**4 3 2 1**

History and evolution o[f]	36	*Students will develop an understanding of the influence of technology on history.* 瞭解: 科技如何影響歷史	2.917	0.881	**4 3 2 1**

of technology 科技演進史	39	*Knowing that making tools and processing new materials from natural materials advance the technology; besides, putting parts together to create systems and cooperating all specialized skill workers to solve sophisticate problems contribute to the modern technology.* 瞭解: 製造工具及從天然材料中製造出新材料，促進科技的進步; 此外，把各組件結合成一完整的系統以及協調各類技術人力解決複雜問題，促成現代化的科技	2.792	0.977	**4 3 2 1**
	41	*Compare qualitatively and quantitatively the performance of a contemporary manufactured product, such as a household appliance, to the comparable device or system 50-100 years ago (ITEA, 2000).* 能做一性能的比較: 以目前的家電設備和 50 到 100 年的同類家用設備做比較，要有量的比較和質的比較	2.917	0.881	**4 3 2 1**

Agricultural, medical, and bio-technologies **農業醫藥及生化科技**	43	*Knowing that medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. Medical technologies extend the effectiveness of medical care and increase people's wealth.* 瞭解: 醫藥科技包括預防、復健、疫苗、醫藥、醫療及開刀、基因工程，及健康維護系統; 醫藥科技使醫護更為有效及增進人類福祉	2.708	0.806	**4 3 2 1**
	45	*Knowing that conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality.* 瞭解: 資源保育包括如防制土壤流失、河道沖蝕、保留水源，改良水質等	3.042	0.751	**4 3 2 1**
	46	*Knowing that people in unsafe and remote areas can get medical care, such as being diagnosed or getting treatment with telemedicine. Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology.* 瞭解: 遠距醫療可使偏遠地區的人受到醫療服務，它是指運用各種較進步的科技，譬如醫藥、電傳、擬真、電腦工程、資訊學、人工智慧、機械人、材料科學、和認知心理學等	2.75	0.944	**4 3 2 1**

	47	*Knowing that the development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food.* 能了解: 冷藏、冷凍、脫水、保存、輻射等科技方法能使食物保鮮而保護人体健康	2.833	0.868	**4 3 2 1**

Energy and power, transportation technologies 能源動力及運輸科技	50	*Knowing that power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.* 瞭解: 動力是能源換型態的速率，亦即做功的速率	2.875	0.85	**4 3 2 1**
	52	*Knowing that processes, such as receiving, holding, storing, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently.* 瞭解: 運輸系統賴“ 處理/程序” 以有效的運作; “ 處理/程序” 包括接收、固持、儲存、搬運、卸載、傳遞、評估、市場行銷、管理、溝通、及遵照規範等	2.917	0.83	**4 3 2 1**
	55	*Knowing that transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture.* 瞭解: 運輸系統對其他科技系統扮演重要角色; 譬如製造、營建、溝通、衛生及安全、及農業等科技	2.958	0.69	**4 3 2 1**

Computer and information technologies 電腦及資訊科技	58	*Knowing that information and communication systems are made up of a source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. These systems can be used to inform, persuade, entertain, control, manage, and educate.* 瞭解: 資訊與傳播系統的組成部門有: 訊息來源、編碼、傳遞、接收、解碼、儲存、檢索、終點等; 本系統的功用可分為: 通告、解釋、娛樂、控制、管理、和教育	3	0.885	**4 3 2 1**
	63	*Use a variety of media and formats to communicate information and ideas effectively to multiple audiences (ITEA, 2000).* 能對不同的聽眾，採用不同的媒体及不同的格式來溝通資訊及發表意見	3.25	0.794	**4 3 2 1**

	65	*Knowing that manufacturing processes include designing products, gathering resources, and using tools to separate, form, combine materials in order to produce products, and servicing of products and systems. Servicing is included because it keeps products in good operating condition.* 能說明製造流程包括: 設計產品、集結資源、採用工具械加工，譬如分解、成形、組合，或修護產品或系統; 其中修護是用來使產品維持在、能良好的運作的狀態	3.167	0.761	**4 3 2 1**
	66	*Be able to design, fabricate models of construction, and work with other classmates in making a planned model community.* 能和同學一起合作，來設計、製作建築模塊、以完成一個社區模型	3.125	0.68	**4 3 2 1**
	67	*Knowing that the product design utilizes a broad range of manufacturing processes, such as metal forming, injection molding, rapid tooling, machining, abrasive water jet cutting, and finishing operations.* 能說明產品設計包括廣泛的製造流程: 譬如金屬成形、模具射出成形、快速加工、機械加工、水砂研磨切割、及拋光表面加工	2.75	0.944	**4 3 2 1**
	68	*Understand that: Structures are constructed using a variety of processes and procedures. Structures require maintenance, alternation, or renovation periodically to improve them or to alter their intended use.* 瞭解: 結構体是運用一定的程序及方法來完成的; 營建結構需要定期進行: 維護、修改、更新、以滿足或超越原訂的使用目的	2.917	0.717	**4 3 2 1**
	70	*Able to explain how products are manufactured, operated, maintained, replaced, and disposed of and who will sell, operate, and take care of it. The cost associated with these functions may introduce yet more constrains on the design (ITEA, 2000).* 能說明產品是如何: 製造、操作、維護、更換、銷毀，以及誰來銷售、操作、及管理或處理它; 並能說明上述各處理之成本，會影響設計時的考量	3.083	0.776	**4 3 2 1**

Applying the design process and engineering design 設計的程序	75	*Knowing that a prototype is a working model used to test a design concept by making actual observations and necessary adjustments (ITEA, 2000).* 瞭解：原型如何用於測試及修改設計構想	3.174	0.778	**4 3 2 1**

Innovation, problem solving, troubleshooting, R&D, and experimentation 創造發明解決問題及故障排除及實驗	78	*Explain how technological inventions and innovations stimulate economic competitiveness and how, in order for an innovation to lead to commercial success, it must be translated into products and services with marketplace demand. Explain through examples how some inventions are not translated into products and services with market place demand, and therefore do not become commercial successes. Describe the process that an inventor must follow to obtain a patent for an invention.* 瞭解：科技之創新及改良如何刺激經濟競爭，如何創造出符合市場需求的“ 產品” 及“ 服務”；能舉例說明那些產品或服務因為未能符合市場需求而以失敗收場；並瞭解：如何為新的發明申請專利	2.739	0.864	**4 3 2 1**
	80	*Knowing that troubleshooting is a problem solving method used to identify the cause of a malfunction in a technological system.* 瞭解：故障診斷是指對一科技系統之故障，以解決問題的方法，調查其可能的原因	3.043	0.706	**4 3 2 1**
	81	*Explain and demonstrate several solutions to a problem or opportunity using technological design, tools, careful planning, experimentation, and testing.* 能展示及說明：如何針對問題或“ 機會” ，採用科技設計、工具、仔細的計劃、進行實驗及測試	3.087	0.596	**4 3 2 1**
	82	*Knowing that research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace.* 瞭解：“ 研究與發展” 是工商業運用解決問題的方法，來發展器材或系統滿足市場需求	3.13	0.869	**4 3 2 1**

	83	*Describes and implements basic troubleshooting techniques for multimedia computer systems with related peripheral devices.* 瞭解: 如何進行多媒体電腦之故障診斷	2.87	0.869	**4 3 2 1**
	84	*Knowing that troubleshooting is a way of finding out why something does not work so that it can be fixed (ITEA, 2000).* 瞭解: 故障診斷是找出故障原因以便以修復	2.87	0.815	**4 3 2 1**

To maintain systems and products 系統及產品之維護	87	*Demonstrate the ability to select, operate, maintain, troubleshoot, and dispose of technological devices in the context of a career (e.g., use the tools of accounting in a real or simulated business environment.)* 能展示能力: 在某一行職業工作崗位上，能選用、操作、維護、及處理“ 科技器材設備” ，譬如在實際的、或模擬的、會計工作崗位上，使用有關設備	2.478	0.898	**4 3 2 1**

Accessing, using, and managing the technology 接近使用及管理科技	95	*Describe new management techniques (e.g., computer-aided engineering, computer-integrated manufacturing, total quality management, just-in-time manufacturing), incorporate some of these in a technological endeavor, and explain how they have reduced the length of design-to-manufacture cycles, resulted in more flexible factories, and improved quality and customer satisfaction.* 能說明新的管理技術: 譬如電腦輔助工程、電腦整合製造、全面品質管制、即時製造等是什麼意思; 並能指出當運用它們於一項科技作業時，它們能如何的縮短設計製作流程，而產生更具彈性的工廠、更高品質、及令顧客更滿意	2.565	0.896	**4 3 2 1**
	97	*Help to manage a group engaged in planning, designing, implementation, and evaluation of a project to gain understanding of the management dynamics.* 能展示對管理實務的理解: 譬如幫助一群人進行某一作業之規劃、設計、執行、及評估	2.391	0.891	**4 3 2 1**

Problem solving, creative, critical, systems and reasoning thinking 解決問題、創作、關鍵思考、系統思考、及理性思考	100	*Knowing that asking questions and making observations helps a person to figure out how things work. Besides, Knowing that the process of experimentation, which is common in science, can also be used to solve technological problems.* 瞭解：觀察及提出問題可用來瞭解事務之運作原理； 並瞭解：科學實驗方法也可用來解決科技問題	3.083	0.503	**4 3 2 1**
	103	*Be able to compare, contrast, and classify collected information in order to identify patterns.* 能展示：如何採用比較、對照、分類等方法來搜集資料，以確認模式	2.833	0.564	**4 3 2 1**
	105	*Knowing that systems thinking applies logic and creativity with appropriate compromises in complex real-life problems and involves considering how every part relates to others (ITEA, 2000).* 瞭解：系統思考是運用邏輯和創造力，並牽就現實情境，從不同角度來衡量問題、並且考量各部門的關係	2.5	0.722	**4 3 2 1**

[Question #2]: The most appropriate Non-Paper and Pencil Test can be used to assess technological literacy needed by 9th graders in Taiwan

([問題 #2]: 徵詢 那種非紙筆測驗 較適於用來測量各科技能力**)**

***Instruction*：**

Five most commonly employed non-paper and pencil tests are selected in this study to investigate the opinions of experts in Taiwan. Please check the appropriate tests for each type of the benchmarks, which are listed in the left hand columns of the following table and are affixed with example. More than one test checked is reasonable.

填答方式：

請參攷隨附之各類“非紙筆測驗”評量方法的評量表，以掌握本問卷各評量方法之意涵。

下表左欄是一般科技能力技能指標常呈現的幾種類型； 下表右側各欄則是各類評量方法。

請發表高見--到底各採用那些評量方法為宜? 煩在適當的空格中打鉤 (可以不只鉤一個)

The Various Performance of Technological Literacy 各類科技能力	**<u>Assessment Methods</u>** 各類評量方法

	Teacher's Observation 教師觀察	Oral Presentation 口頭報告	**Essay** 書面報告	**Project** 專題製作	**Portfolio** 學習歷程檔案
<Example> To be able to check and send e-mail <舉例]> 會收發電子郵件	√				√

<以上為舉例，以下為正式問卷>

The Various Performance of Technological Literacy 各類科技能力	**Assessment Tasks** 各類評量方法				
	Teacher's Observation 教師觀察	Oral Presentation 口頭報告	**Essay** 書面報告	**Project** 專題製作	**Portfolio** 學習歷程檔案
[1] *Technological literacy which are visualized when students showing their understanding of the fundamental concepts of technology and the characteristics of technology.* 科技的知識，科技概念、及對科技的瞭解					
[2] *Technological literacy which are visualized when students are able to investigate, assess, organize, and use information; as well as able to define, identify, defend, justify, support, validate, describe, appraise, explain, illustrate, interpret, analyze, compare, critisize, or evaluate.* 能搜集、整理、判斷、及運用資料；並加以描述、解釋、界訂、論証、分析、比較、對照、評斷、評估、的科技能力					
[3] *Technological literacy which are visualized when students are able to use media, symbols, and formats to communicate observation and ideas.* 會運用符號、媒体等來有效溝通、表達					
[4] *Technological literacy which are visualized when students are able to assemble or disassemble, to use tools, materials, and machines, and to design and fabricate models.* 會設計、製作、拆裝、及使用工具等工作					
[5] *Technological literacy which are visualized when students are able to apply technological concepts and processes, to select, maintain, troubleshoot, and to solve technological problems.* 會應用科技觀念、會選用、維護、故障處置、及解決科技問題					

REFERENCES

AAAS. (2002). Benchmarks for Science Literacy. The Project 2061 Benchmarks. The American Association for the Advancement of Science. Washington, DC.

Accenture (2002). The New Rules Of Global Competitiveness: Challenges Facing Taiwan. Retrieved February 22, 2003, from the World Wide Web: http://serviceexcellence.com.tw/Eng/guestspeech_eng.htm

Altschuld, J. W., & Witkin, B. R. (2000). From Needs Assessment to Action: Transforming Needs into Solution Strategies. Sage Publications: Thousand Oaks, CA. Source: Greg Hall, Alberta Education Department

AOBJ (2000). Assessment - On-balance Judgments. Assessment Classroom Approaches. Focusing on outcomes. Retrieved February 20, 2001, from the World Wide Web: http://www.eddept.wa.edu.au/centoff/outcomes/focus/fc4212.htm#1

APS (2001). Trainning Management Software. Advanced Personnel Systems. Retrieved May 24, 2001, from the World Wide Web: http://www.hrcensus.com/pdf/trngall.pdf

ARCA (2000). Review Classroom Approaches to Student Assessment. Assessment Review Classroom Approaches. Focusing on outcomes. Retrieved June 12, 2002, from the World Wide Web: http://www.eddept.wa.edu.au/centoff/outcomes/focus/fc42.htm#1

Arter, J. A. (2001). Scoring rubrics in the classroom: using performance criteria for assessing and improving student performance. Thousand Oaks, CA: Corwin Press.

BCMOE (2001). Rationale for Technology Education. Retrieved February 20, 2001, from the World Wide Web: http://www.bced.gov.bc.ca/irp/te_dd1112/rationale.htm

Biggs, B. T. (2000). Arkansas, Content Standards/Frameworks Overview. Bobbie T. Biggs, AWECC, Retrieved January 14, 2001, from the World Wide Web: http://www.uark.edu/depts/awecc/content/

Black, S. (1995) Response to “Should you include a "don't know" or "no opinion" category in questionnaires?” Retrieved August 22, 2002, from the World Wide Web: http://oassis.gcal.ac.uk/teaching/rms/misc/dknow.html

Boser, R. A. , Palmer, J. D, and Daugherty M. K (1998) Students Attitudes Toward Technology in Selected Technology Education Programs. The Journal of Technology Education, 10(1), Fall 1998.

Brookhart, S. M. (1999). The Art and Science of Classroom Assessment: The Missing Part of Pedagogy. ASHE-ERIC Higher Education Report (Vol. 27, No.1). Washington, DC: The George Washington University.

Brown, S., & Glasner, A. (1999). Assessment matters in higher education : choosing and using diverse approaches. Buckingham [England] ; Philadelphia, PA : Society for Research into Higher Education & Open University Press, 1999. / Sally Brown and Angela Glasner

California Department of Education (1995). Assessment: California School-to-Work Handbook. California Department of Education. Sacramento, CA.

Calstatela (1999). Frequent asked questions. California State University, Los Angeles. College of Engineering, Computer Science, and Technology.

Campbell, Cignetti, Melenyzer, Nettles & Wyman (1997). How to Develop a Professional Portfolio: A Manual for Teachers. California University of Pennsylvania. California, PA

Campbell, D. M. et al. (2000). Portfolio and performance assessment in teacher education. Boston : Allyn and Bacon.

Cangelosi, J. S. (2000). Assessment strategies for monitoring student learning. New York : Longman, c2000. / James S. Cangelosi

CCJH (2001). The new regulation about grading and assessment. Deptment of Education, City Government of Taipei.

CGEA (1997). Generic Information sheet 3. The Adult, Community and Further Education Board, Victoria, Certificate for general education for adults.

Chang, H. C. (1999). Graduate Institute of Applied Statistics, Tamkang University. Master thesis. Dept. of Statistics. Tamkang University. Hui-Chen.

Chang, Y. S. (1993). Planning for adult Technology Education's program. Master thesis. National Kao-Hsiung Normal University, Kao-Hsiung, Taiwan. Yuh-Shan

Chen, H. J. (2000). The comparison the effectiveness of multiple assessments. Master thesis, Dept. of physics. National Taiwan Normal University. Hwa-Jie.

Chen, I. (2002). Constructivism. Retrieved September 28, 2001, from the World Wide Web: http://pdts.uh.edu/~ichen/ebook/ET-IT/constr.htm

Chen, S. F. (1995). A Study of competencies and related content in Living Technology education for junior high school teachers. Dissertation. NTNU. Sheng-Fang Chen.

Chen, F. J. (1998). A Case Study of Implementation of Arts and Working Curriculum in Primary Schools in Taiwan. Master Thesis. National Taipei Normal College.

Chen, Y. R. (1999). A Study of Implementation of Performance Assessment in Mathematic courses in Elementary Schools in TaiChung. Master Thesis. National TaiChung Normal College.

Chiang, C. P. (2000). Chiang (2000). Student Assessment in Technology Education in Junior High School. Thesis. National Taiwan Normal University. Chiu-Ping

Christensen, M. (1995). Critical Issue: Providing Hands-On, Minds-On, and Authentic Learning Experiences in Science. North Central Regional Educational Laboratory. (NCREL), Naperville, Illinois.

Crehan, K. (1991). Performance Assessment: Comparative Advantages. ERIC_NO: ED338710.

Curriculum Frameworks Project (2000). Arts Framework. Chapter 5: Assessment. Alaska Department of Education & Early Development.

DATAS (2003) Dissertation and Thesis Abstract System. ROC. Retrieved July 12, 2003, from the World Wide Web: http://datas.ncl.edu.tw/theabs/1/

Department of Statictics (2003). The 28 week of 2003 statistic report. The Ministry of the Interior, ROC. Retrieved July 12, 2003, from the World Wide Web: http://www.moi.gov.tw/W3/stat/home.asp

Der-jen Hung (2002). The Implementation of Authentic Assessment in the Teaching and Learning of Elementary Social Studies. Master thesis, Dept. of elementary education. Chi-Yi University.

Dimmock, D., & Walker, A. (2000). Future School Administration: Western and Asian Perspectives. Educational Studies Series.

Din, F. S. (2002). The evaluation criteria of the curriculum plan on the subject of Science and Living Technology's learning field study in elementary schools. Maaster Thesis. Taipei Nomal College.

DOEOFM (1996). Performance Measurement. Department of Energy, Office of Field Management. July 1996. Good Practice Guide GPG-FM-020.

Dominick, P.G. et al. (2001). Tools and tactics of design. New York : John Wiley, 2001. / Peter G. Dominick ... [et al.]

Dyrenfurth, M. J., & Kozak, M. R. (Eds.). (1991). Technological literacy: 40th yearbook of the Council on Technology Teacher Education. Peoria, IL: Glencoe.

EJE (2000). Multiple Assessment Development Plan. Ministry of Education. The Republic of China. http://class.eje.isst.edu.tw/files/20000727.

EJE. (2002). 9 year coordinated curriculum T&L web site. Office of Elementary and Junior High School Education. Ministry of Education. The Republic of China.

ERIC/AE. (1997). Designing structured interviews for educational research. Practical Assessment, Research & Evaluation, 5(12). ERIC/AE Staff. Available online: Retrieved February 22, 2003, from the World Wide Web: http://ericae.net/pare/getvn.asp?v=5&n=12.

ETI. (1997). Evaluation of the Career-Technical Assessment Program (C-TAP). Final report submitted to the Sacramento County Office of Education. Los Angeles: Evaluation and Training Institute.

ETS (1999). Accreditation. Environmental and Technology Studies. Retrieved January 23, 2001, from the World Wide Web: http://www.stcloudstate.edu/~ets/department/accredit.html

EVALCTR (2000). Teacher Evaluation Kit. Complete Glossary. Glossary Overview. Evaluation Center. Western Michigan University.

Fang, C. H. & Yang, J. S. (1996). A Study on the Contents of Technological Literacy for the Elementary School Students. Taipei : National Science Council. (NSC85-2511-S-003-070) Fang, Chung-Hsiung and Yang, Jing-Shin

Fang, R. J. & Yang, H. J. (1996). Elementary school technology education in Taiwan: An Analysis of Implementing Policies. Retrieved June 24, 2001, from the World Wide Web: http://www.ep.liu.se/ecp/005/13/00513b.pdf.

Finch, F. L., & Dost, M. A. (1992). Toward an Operational Definition of Educational Performance Assessments. ERIC Document Rereproduction Service NO: ED353287

Forcier, R. C. (1999). The Computer as an Educational Tool: Productivity and Problem Solving (Second Edition). Upper Saddle River, NJ: Merrill,

Fosnot, C. T. (Editor). (1996). Constructivism: theory, perspectives, and practice. New York: Teachers College, Columbia University. Catherine Twoney Fosnot, Editor, Pub Date: 1996, 240 pages

Fuchs, L. S. (1995). Connecting Performance Assessment to Instruction: A Comparison of Behavioral Assessment, Mastery Learning, Curriculum-Based Measurement, and Performance Assessment. ERIC Digest E53

Gay, L.R. (1996). Educational Research: Competencies for Analysis and Application. Prentice-Hall, Inc.

GIO (2001). The Republic of China yearbook 2001. Government Information Office. Retrieved February 22, 2003, from the World Wide Web: http://www.gio.gov.tw/taiwan-website/5-gp/yearbook/chpt17-3.htm

HCPS. (2001).The Hawaii Content And Performance Standards (Hcps). Career And Life Skills Content Standards. Curriculum and Instruction Branch • Department of Education • State of Hawai'i • Retrieved March 29, 2002, from the World Wide Web: http://research.osdcate.hawaii.edu/reports/DOE%20Reports/accn.pdf

Hibbard, K. M., et al. (1996). A teacher's guide to performance-based learning and assessment. Alexandria, VA: Association for Supervision and Curriculum Development.

Hill, C., & Larsen, E. (1992) Testing and Assessment in Secondary Education: A Critical Review of Emerging Practices. Berkeley, CA: National Center for Research in Vocational Education, 1992. Hill, Clifford, and Eric Larsen.

Howard M. H., and Wheeler, B. (2000). Heuristics: The Technology of Good Ideas. School of Vocational Technology and Arts Education. Griffith University. Queensland, Australia.

HRDC. (1997). Literacy skills for the knowledge society : further results from the International Adult Literacy Survey. [Ottawa] : Human Resources Development Canada, organization for Economic Co-operation and Development (OECD).

Hsu, M. C. (1994). Development of a Technological Literacy Test for Junior High School Students. Master Theses. Industrial Arts Education, National Kaohsiung Normal University. Mau-Chien

Huang, S. T. (1994). An analytical study of the content of technological literacy in senior high school textbooks. Unpublished master thesis. National Kao-Hsiung Normal University, Kao-Hsiung, Taiwan.

Huang, S. Y. (2002). The teaching experience of Arts and Labor courses. The Development of School-based Curriculum. July 2002., PP.148-155.

Husted, K. (1999). Testing the Real Thing: Show Me What You Can Do. ERIC_NO: EJ596906

IALS (1995). A NOTE CONCERNING LITERACY LEVELS. The 1995 International Adult Literacy Survey (IALS). Retrieved March 22, 2002, from the World Wide Web: http://www.nald.ca/fulltext/revcan/page07.htm

IDE (1999). Rubric to Assess a PBL and Rubric. IDE Corp. Retrieved February 20, 2001, from the World Wide Web: http://www.idecorp.com/assessrubric.pdf

IDEA (2002a). (Internet Digital Education Association. Retrieved February 20, 2002, from the World Wide Web: http://www.idea-tw.net/04teach/04_9_year001-1.htm

IDEA (2002b). (Internet Digital Education Association. Retrieved February 13, 2002, from the World Wide Web: http://www.idea-tw.com.tw/resources/9-year/9_year001-3.html

ISTE. (2000). National Educational Technology Standards.

ISTE/NCATE. (2001). Educational Computing and Technology Facilitation Standards Rubric. Retrieved March 22, 2002, from the World Wide Web: http://cnets.iste.org/ncate/FacRubric.html

ITEA. (1996). Technology for all American: A rational and structure for the study technology. Virginia: International Technology Education Association.

ITEA. (2000). Standards for technological literacy. International Technology Education Association.

ITEA. (2003). Advancing Excellence in Technological literacy: Student Assessment, Professional Development, and Program Standards. International Technology Education Association.

Jahn, B. (2001). Technology Literacy Standards for High School Graduation. TIPS Project, Summer 2001. Retrieved March 9, 2001, from the World Wide Web: http://www.online2.org/tips-project/TIPS-Project.htm#tips_project_goals

Jin-Chun Liu (1994) A study of the content of transportation literacy education in the level of junior high schools. Master thesis, Kao-Hsiung Normal University, Dept. of Industrial Arts Ed.

Jobin, R. A. (1991). Trains, tracks, and nodal regions. Journal of Geography, 90(4), 160-163.

Joels, K. M. (2001). Future Studies: An Interdisciplinary Vehicle for Space Science Education. National Air and Space Museum. Retrieved September 28, 2001, from the World Wide Web: http://www.jsc.nasa.gov/er/seh/future.html.

Jonassen, D. (1994). Thinking technology: Toward a constructivist design model Educational Technology, 34(4), 34-37.

Kan, L. (2000). A Discussion on the Problems to Determine the Exact Year between Shang and Chou Periods. /Lao Kan. Retrieved March 21, 2002, from the World Wide Web: http://saturn.ihp.sinica.edu.tw/~bihp/67/67.2/laokan.html

Khattri, N., Reeve, A. L., & Kane, M. B. (1998). Principles and practices of performance assessment. Mahwah, N.J. : L. Erlbaum Associates.

Klajman, G. (1995) Response to "Forced-choice item provide more usable data?" Retrieved August 8, 2002, from the World Wide Web: http://oassis.gcal.ac.uk/teaching/rms/misc/dknow.html

Kubiszyn, T., & Borich, G. (2000). Educational testing and measurement : classroom application and practice. New York : J. Wiley & Sons, c2000.

Kuo, W. F. (1983). Nation-wide College Entrance Examination--Current Practice and Critical Issues. 13p.; Paper presented at the International Symposium commemorating the tenth anniversary of the University of Tsukuba. Japan.

Lang, T. (1998). An overview of four futures methodologies. (Delphi, Environmental Scanning, Issues Management and Emerging Issue Analysis). Retrieved February 26, 2001 from the World Wide Web: http://www.soc.hawaii.edu/~future/j7/LANG.html

Latting, J. (1992). Assessment in Education: A Search for Clarity in the Growing Debate. Berkeley, CA: National Center for Research in Vocational Education, 1992.

Lee, C. Y. (1999). Reliability and validity of problem-solving assessments for Taiwanese high school students (China). UMI digital dissertations: AAT 9955067. Retrieved November 18, 2001, from the World Wide Web: http://wwwlib.umi.com/dissertations/preview/9955067

Lee, L. S. (2000). Technology Education Reform in Taiwan. Paper presented at the Biennial International Conference on Technology and Education (Canberra, Australia, January 10-14, 2000).

Liao, T. T. (1998). IDEAS 1. Technological Literacy: Beyond Mathematics, Science, and Technology(MST) Integration. Retrieved February 28, 2002 from the World Wide Web:http://scholar.lib.vt.edu/ejournals/JTS/Summer-Fall-1998/PDF/ideas.pdf.

Lindstone, H. A. and Turroff, M.: (1975). The Delphi method: techniques and applications. Massachusetts, Addison-Weslwy, 1975: 3-12.

Liu, Katherine. (1995). Rubrics Revisited. The Science Teacher. October, 1995. Pages 49-51. Retrieved December 25, 2001, from the World Wide Web: http://www.accessexcellence.org/21st/SER/JA/rubrics.html

Liu, S. M. (2000). A study of new directions in Taiwan's education policy. UMI. AAT 9981429. / Liu, Shih-Min.

Lou, W. G. (1995). The content analysis of the course living technology in junior high school curriculum in Taiwan. Industrial Arts Monthly, 28(12), pp. 2-8.

Lu, H. Z. (1999). A Study of the Living Technology Pre-Service Teacher's Distant Guidance System. Master Thesis. Kao-Hsiung Normal University. Hung-Zon.

Lu, S. M. (1998). The promise, difficulties, and Challenges of Performance Assessment. Retrieved March 14, 2002, from the World Wide Web: http://www.nmh.gov.tw/edu/basis3/20/jk2.htm

Ludwig, B. (1997). Predicting the Future: Have you considered using the Delphi Methodology? Journal of Extension. 35(5). October 1997.

MAC (2000). Glossary of Assessment Terms. Maryland Assessment Consortium. Retrieved may 22, 2001, from the World Wide Web: http://www.cep.cl.k12.md.us:2000/resources/glossary.html

Mallet, D. (1997). The identification of principles for the development and implementation of technology education: A case study of Mauritius. Edith Cowan University.

Martin-Kniep, G. O., (2000). Becoming a better teacher: eight innovations that work. Alexandria, Va.: Association for Supervision and Curriculum Development, /

Mau-Chien Hsu. (1994). Development of a Technological Literacy Test for Junior High School Students. Master Theses. Industrial Arts Education, National Kaohsiung Normal University.

Maxwell, G. S. (2001). Teacher Observation in Student Assessment. Prepared for the Queensland School Curriculum Council. The University of Queensland. Retrieved May 5, 2001, from the World Wide Web: http://www.qscc.qld.edu.au/research/pdf/teacher_observation_student_assess_final.pdf

McClure, C. R., and Herndon, P. (1991). Library and Information Science Research - Perspectives and Strategies for Improvement. Information Management, Policy, and Services Series. Ablex Publishing

McCullough, L. L., & Tanner, B. M.(2001). Assessment in the block: the link to instruction. Larchmont, NY : Eye on Education.

McDaniel, E. D., & Soong, W. (1981). Comparisons of Self-Concept Scores of Children in America and in Taiwan. 34p.; Paper presented at a NATO Conference on Human Assessment and Cultural Factors. (Kingston, Ontario, Canada).

McNeil, S. (2001). What is Delphi Technique, Research Inerests. Retrieved April 2, 2002, from the World Wide Web: http://cite502.coe.uh.edu/~smcneil/delphi.htm

Miller, V. (2001). New Definition of Education Standards. Number 185, The Newspaper of Education Rights June 2001. Virginia Miller.

Montgomery, K. (2001). Authentic assessment : a guide for elementary teachers. New York : Longman, c2001. /Kathleen Montgomery.

Moran, J. J. (1997). Assessing Adult Learning. A Guide for Practitioners. Professional Practices in Adult Education and Human Resource Development Series. ERIC_NO: ED401404

Moskal, B. M. (2000). Scoring rubrics: what, when and how? Practical Assessment, Research & Evaluation, 7(3). Practical Assessment, Research & Evaluation: A peer-reviewed electronic journal. ISSN 1531-7714.

Myers, M.D. (1997) 'Qualitative Research in Information Systems.' MIS Qtly 21, 2 (June 1997). 241-242, Retrieved February 25, 2001, from the World Wide Web: http://www.auckland.ac.nz/msis/isworld/

NAE. (2001). Technically speaking: Supporting a modern workforce, The National Academy of Engineering. Retrieved November 25, 2002, from the World Wide Web:http://www.nae.edu/nae/techlithome.nsf/weblinks/KGRG-55SR39

NAS. (1995). National Science Education Standards. National Research Council, National Academy of Sciences. Retrieved May 25, 2002, from the World Wide Web: http://bob.nap.edu/html/nses/html/1.html

NASSP (2002). NASSP Products. Multiple Assessment of Student Progress. National Association of Secondary School Principals.

NCRVE (1995). National Consortium for Product Quality. Dedicated to identifying Quality Curriculum. the National Center for Research in Vocational Education.

NCTM. (2000). Principles and Standards for School Mathematics. The National Council of Teachers of Mathematics. The National Council of Teachers of Mathematics.

Neuman, S. B., & Dickinson, D.K. (2001). Handbook of early literacy research. New York : Guilford Press, c2001. / edited by Susan B. Neuman, David K. Dickinson

Ni, H. Y. (1995). A Study on the Possessed Technological Literacy of Elementary School teachers. Master thesis. National Taiwan Normal University. Dept. of Industrial Arts Ed. Hui-Yu

NIOERAR (2003). Database of full text index on research papers in education. National Institute of Educational Resourses and Research. ROC. Retrieved July 12, 2003, from the World Wide Web: http://192.192.169.230/edu_paper/index.htm

NPHP (2002a). Chapter 3. What Might a National Health Performance Framework Look Like? National Public Health Partnership. Retrieved May 9, 2002, from the World Wide Web: http://www.dhs.vic.gov.au/nphp/perfinds/chapter3.htm

NPHP (2002b). Attachment XV. Some Criteria for Performance Indicators. Performance Indicator Frameworks. National Public Health Partnership. Retrieved May 21, 2002, from the World Wide Web: http://www.dhs.vic.gov.au/nphp/perfinds/attach15.htm

NPRES. (2001). About Qualitative Research/Evaluation. Non-Profit Research and Evaluation Services, Inc. Written August 5, 2001. Retrieved February 24, 2002, from the World Wide Web: http://npres.org/qualitative.htm

NRC (2001). Knowing what students know: The science and design of educational assessment. Washington, DC: National Academy Press. National Research Council.

NTNUITE (2002). Department of industrial technology education homepage. Retrieved July 26, 2001, from the World Wide Web: http://140.122.91.94/.

NUE. (2001). NUE response to the Revised National Curriculum Statement 29 September 2001. National Union of Educators. South Africa.

NYSED. (1996). Learning Standards for Mathematics, Science, and Technology. Albany, NY: The State Education Department, 1996, 103 pgs. (supplementary material, K-12)

OECD (2000). The Programme for International Student Assessment. Retrieved August 5, 2001, from the World Wide Web: http://www.erc.ie/pisa/what.html

Peang, Y. C. (1998). A Study On The In-service Education Needs Of Senior High Schools. Master Thesis. National Taiwan Normal University. Yiang-Chaing

Peng, S. S. (1993). Fostering Student Discipline and Effort: Approaches Used in Chinese Schools. 11p.; Paper presented at the Annual Meeting of the American Educational Research Association (April 12-16, 1993).

Pickett, N., & Dodge, B. (2001). Rubrics for web lessons. updated June 20, 2001. Retrieved October 18, 2001, from the World Wide Web: http://edweb.sdsu.edu/webquest/rubrics/weblessons.htm.

Poon, L. (2003). The Ancient Dynasties. History of China. Army Area Handbook. Retrieved July 12, 2003, from the World Wide Web: http://www-chaos.umd.edu/history/ancient1.html#zhou

Pope, C., and Mays, N. (2000). Qualitative Research in Health Care. Second Edition. BMJ Books. First published in 1996 by the BMJ Publishing Group, London WC1H 9JR. Retrieved March 22, 2002, from the World Wide Web: http://www.bmjpg.com/qrhc/chapter5.html

Porter, A. (1995). Critical Issue: Integrating Assessment and Instruction in Ways That Support Learning. North Cental Regional Educational Library.

Priestley, M. (1985). Performance Assessment in Education and Training. ERIC_NO: ED263178. Priestley, Michael

RCHELT (2002). Introduction to the instructional material media center. The Research Center of Home Economics and Living Technology in Taiwan.

Robinson, M. A. (2000). College Students' Attitudes Toward Portfolio Assessment as an Alternative to Traditional Tests. Posted on ITFORUM November 10, 2000. University of South Alabama.

ROCMOE (1975). Curricula Guidelines for Elementary and Junior High Schools. Ministry of Education. The Republic of China. August 1975.

ROCMOE (1994) The revising history of the curriculum of the junior high schools in Taiwan. Retrieved March 27, 2002, from the World Wide Web: http://www.edu.tw/primary/business/2214app.htm

ROCMOE (1998) Evaluation Rules for Juniro High Schools. Ministry of Education. The Republic of China. August 1998.

ROCMOE (2000). Curricula Guidelines for Elementary and Junior High Schools. Ministry of Education. The Republic of China.

ROCMOE (2001). Guidelines for a 9-Year Joint Curricula Plan for Elementary and Junior High Schools. Ministry of Education. The Republic of China. Promulgated at September 30, 2000, Published at January 2001.

ROCMOE (2002a). Statistics of Schools in Taiwan. The Ministry of Education. Retrieved may 2, 2001, from the World Wide Web: http://www.edu.tw/school/index_a1.htm

ROCMOE (2002b). 9-year integrated Curriculum and Instruction. Ministry of Education. Retrieved May 14, 2002, from the World Wide Web: http://teach.eje.edu.tw/B-list/B-main-frame.htm

ROCMOE (2002c). Education in the Republic of China (2001). Ministry of Education.

SACE (2002). Learning Area Manual 2002. Science. SACE (South Australian Certificate of Education), SABSA (Secondary Assessment Board of South Australia)

Sackman, H. (1974). Delphi assessment : expert opinion, forecasting, and group process. Santa Monica, Calif.: Rand.

Saskatchewan Education. (1991). Assessment and Evaluation. Why Consider Assessment and Evaluation? Retrieved November 29, 2001, from the World Wide Web: http://www.sasked.gov.sk.ca/docs/midlsci/asevmsc.html

SASKED (2001). Assessment and Evaluation: Why Consider Assessment and Evaluation? Retrieved December 24, 2001, from the World Wide Web: http://www.sasked.gov.sk.ca/docs/midlsci/asevmsc.html

SCANS (1998). Learning a Living: A Blueprint for High Performance. A SCANS REPORT FOR AMERICA 2000. Secretary's Commission on Achieving the Necessary Skills, U.S. Department of Labor. Retrieved January 15, 2002, from the World Wide Web: http://wdr.doleta.gov/SCANS/lal/LAL.HTM.

Selfe, C. L. (1999). Technology and Literacy in the Twenty-First Century: The Importance of Paying Attention (Studies in Writing and Rhetoric). Southern Illinois University Press, 1999.

Seven Oaks School Division (2001). Teacher resources. Issue One (Winter 1994). Retrieved March 22, 2002, from the World Wide Web: http://www.7oaks.org/ttt/ttt1.htm

Shi, J. Y. (2002). A Study of Performance Assessment in Life Curriculum for Elementary Schools. Master thesis. Natiional Tai-Chung Techer College. Shi,Jia-Yuh

Spickett, J. (2002). Research Issues. Division of Health Sciences. Updated February 2002. Retrieved September 25, 2001, from the World Wide Web: http://www.curtin.edu.au/cupsa/DFiles/HS_ResIssuesGuide_2-02.doc

Stiggins, R. J. (1994). Student-centered classroom assessment. New York: Macmillan Publishing Company.

Sturges, D. L. (1990). "Using Magnitude Estimation Scaling in Business Communication Research", Journal of Business Communication. 27(4). pp417-427;

Su, J.D. (1994). Study on the technological literacy of 5th and 6th graders in Kuo-Hsuong Area of Taiwan. Master thesis. National Kao-Hsiung Normal University. Jin-Dun

Synder-Halpern, R., Thompson, C. B., & Schaffer, J. (2000). Comparison of Mailed vs. Internet Applications of the Delphi Technique in Clinical Informatics Research. College of Nursing Clinical Informatics Program, University of Utah, Salt Lake City, Utah.

TAAP (1996). Technology for all Americans: A rationale andstructure for the study of technology. Technology for All Americans Project. Reston, VA: International Technology EducationAssociation.

Tanner, D. E. (2001). Assessing academic achievement / David E. Tanner. Boston : Allyn and Bacon, c2001

TechTarget (2001). Benchmark. Retrieved December 29, 2001, from the World Wide Web: http://searchsystemsmanagement.techtarget.com/sDefinition/0,sid20_gci211650,00.html

The UK Technology Education Center. (1996). Technology Education: An Amalgam of Disciplines. What is technology education. Curriculum Philosophy. Retrieved October 25, 2001, from the World Wide Web: http://atschool.eduweb.co.uk/trinity/watisted.html

Trice, A. D. (2000). A handbook of classroom assessment. New York: Longman, c2000. /Ashton D. Trice

Tyler, R.W. (1949) Basic Principles of Curriculum and Instruction. Chicago: University of Chicago Press. p.44

United Daily (1997). Admission to college without entrance exam for high shool students in Taiwan. 5th edition. 1997/7/9.

Wang, J. R. (2001). Improving Elementary Teachers' Understanding of the Nature of Science and Instructional Practice. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching. St. Louis, MO.

WDPI (1998). Wisconsin's Model Academic Standards for Technology Education. Wisconsin Department of Public Instruction Madison, Wisconsin.

Wheeler, P. H. (1993). Methods for Assessing Performance. EREAPA Publication Series No. 93-6. ERIC_NO: ED374161

Wood, K. D., and Dickinson, T. S. (2000). Promoting Literacy in Grades 4-9: A Handbook for Teachers and Administrators. Boston: Allyn and Bacon.

Yang, R.S. (1999). The content of technological literacy of arts and work teachers in elementary schools in Taiwan. Academic Reports of Hwa-Liang Teacher College. June 1999. pp. 307-342.

Zhang, D. T. (1995). The study on the implementation of assessment in junior high schools in Taiwan. Master thesis. Dept. of Education. National Taiwan Normal University.

Ziglio, E. (1996). The Delphi method and its contribution to decision-making. In “Gazing into the oracle: The Delphi method and its application to social policy and public health.” London: Jessica Kingsley Publishers Ltd.