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PROBLEM SOLVING IN TECHNOLOGY EDUCATION AT THE SECONDARY LEVEL
AS PERCEIVED BY TECHNOLOGY EDUCATORS IN THE UNITED KINGDOM AND
THE UNITED STATES

Dissertation

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
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The Ohio State University
1996

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ABSTRACT

The purpose of this study was to compare the definition, curriculum, and implementation of problem solving in technology education in the United Kingdom and the United States. Participants in the study were drawn from key experts of problem solving in technology education.

The questionnaires were mailed and collected using postal mail and e-mail after field testing and pilot testing of the instrument developed by researcher. Responses to the questions were analyzed as follows: (a) the items in each question were rank ordered by mean scores and a calculated Spearman rank-order correlation (rho), and (b) responses to the problem solving definition were analyzed by content analysis.

Findings of this study were as follows:
1. Problem solving in technology education was defined and explained by 'design' and 'process', in both nations.
2. The most agreeable goals of problem solving perceived by the experts were 'develop thinking skills' in the United States, and 'develop designing skills' in the United Kingdom.
3. Both United States and British experts perceived problem solving processes as the best pertinent curriculum content of problem solving in technology education.

4. Technology educators recognized the following as the fittest instructional strategies for problem solving: project or activity methods in the United Kingdom and brainstorming in the United States.

5. Both American and British experts on problem solving recognized ‘involve students in meaningful dialogue’ as the best suitable teacher’s instructional activity. The behavior pattern of the teacher that respondents felt most appropriate to problem solving instruction was as a facilitator in the two countries.

6. ‘Design portfolio’ was considered as the most appropriate assessment format of problem solving in the two nations. Criterion-referenced testing was considered as a more appropriate assessment method for problem solving than norm-referenced testing in both countries. British technology educators perceived that a formative evaluation was the most appropriate method while American experts perceived a summative evaluation.

7. British educators estimated that around 54% and 59% were the appropriate proportions of problem solving activity to be included in a technology education program for middle school and high school students respectively while American experts estimated around 60% and 66%.
Dedication

This dissertation is dedicated to my parents,

Jongduk Yi and Yongkum Kim,

for their self-sacrificing support for me with love
and to have educated me with the values of life
through their own sincere lives.
ACKNOWLEDGMENTS

I wish to express my sincere appreciation for the contribution of my parents, Jongduk Yi and Yongkum Kim, for their life-long reinforcement of the values which have led to the pursuit of this degree.

I would like to thank the members of my dissertation committee, Dr. Michael L. Scott for his kind help and encouragement. Another committee member who I appreciate is Dr. Janet L. Henderson. This dissertation work cannot be completed without her help in research method and scrupulous feedback. A special thank you is extended to my advisor and chairperson of the committee, Dr. Karen F. Zuga. I express sincere appreciation to Dr. Karen Zuga for her guidance and advice throughout the preparation of this dissertation study. Especially, I would like to thank her for the critical thinking and insights into education that I learned from her.

A special warm thanks is offered for the participants of the field test, the pilot test, and the survey for the dissertation. I am so much obliged to them for their high levels of expertise and courtesy.
A final word of thanks is offered to my wife, Sunsuk Lee, whose patience supported this effort at every turn.

I cannot forget that my mother in law, Hyunsuk Shin, maternal grandmother, Dui Son, and sister, Bokre Yi have prayed for my successful study in the United States and completion of the dissertation. I greatly appreciate their supports from the bottom of their hearts. Finally, I would like to share gratification of accomplishing a Ph.D. Degree with my children, Gyore and Garammoe.
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CHAPTER 1

INTRODUCTION

It is impossible to establish the purpose and goals of education in absolute terms because they can not be defined independently of the culture and institutions of the society of which they are a function. Education exhibits both the substance and structure of the culture and is basic to both the stability and movement of social institutions. (Deighton, 1971, p.147)

Technology today is everywhere. How people use technology is more important than ever because technology affects almost every aspect of life. After the Industrial Revolution in the early 19th century, as a result of the growing use of technology, the world has greatly changed from paper and pencils to computers in offices, from pottery ovens to microwave ovens in kitchens, from carriages to racing cars on the road, and from telegraphs to telecommunication on line. The rate of change and advancement of technology is anticipated to increase at an accelerating pace. This increasing importance and influence of technology use, not only on the economy, but also on social and home life for the last few decades has created significant educational change in goals and new curriculum developments.
Change of educational goals and curriculum is a remarkable phenomenon in the late 1900s. The changing world today is redefining the role of education. The rapidly changing and advancing technology and domestic and international competition brings new challenges and problems to educators. The explosion of knowledge for the last few decades, due to the rapid advancement in science and technology in modern society, has made learning content by merely providing facts meaningless and impossible for children. This social and educational condition explains why there is an increasing demand for new curriculum development to meet "the way we educate in order to develop the full range of learning skills" (Sellwood, 1989, p.3). Educational goals and school curriculum should reach far beyond the traditional content of disciplines (Marzano, Pickering, & McTighe, 1993). One of the major directions of educational reform is that more emphasis should be placed on higher order thinking skills such as critical thinking, problem solving and decision making as important requirements of students for the world of tomorrow (Cawelti, 1993; Stevens, 1992).

Historically, problem solving has been included in the curriculum of areas such as mathematics, science, and social studies education (Britz & Richard, 1992; Drum & Wells, 1984). Recently, problem solving has been spread to every subject of the elementary and secondary school curriculum as an important curriculum component or major goal by increasing the importance
of the development of problem solving skills to meet societal changes (Britz & Richard, 1992; Drum & Wells, 1984).

More recently, teaching students how to solve problems has become a major goal, an essential element of curriculum, or both in the field of technology education (Bame & Miller, 1980; DeLuca, 1991; Dyrenfurth, 1994; Savage & Sterry, 1990; Waetjen, 1989; White, 1990). However, the meaning of the term 'problem solving' is obscure and perceived in various ways (Boser, 1993). In addition, diversified types of problem solving instruction are used in a variety of educational settings. In other words, there has been an uncertainty about how best to teach and evaluate problem solving and what kind of activities are best for teaching problem solving. According to Hennessy and McCormick, "a basic confusion exists between problem-based learning and teaching problem-solving methods" (1994, p. 94). Due to the lack of understanding of problem solving, there has been a tendency to shun or hesitate to use problem solving that encourages and develops students' thinking (Costa, 1985, p. 4).

Another significant educational change created by the influence of technology is the development of new curriculum and the inclusion of technology education as an integral part of general education. The use of contemporary technology in an evolving world has changed the role of technology in the field of education. Because of the increasing influence of the use of
technology on society and personal life, inclusion of technology education into the school curriculum has been a significant curriculum development in the international education field for the last few decades.

Historically, technology education has been an occupation-related program in the field of vocational education. Although technology education has been a part of general education, often, the program has been limited and gender-biased for selected groups of secondary students (Jenkins, 1994). The increasing importance and influence of technology on humans and society is forcing general educators to include technology education to help students understand technology, use technology wisely, and know how to control technology for the sake of the improvement of the quality of human life and society. Vocationally oriented technology education was acceptable then and technology education as an integral part of general education is needed now.

As a result of technology education which is becoming a component of general education, there has been significant curriculum development in international education for the last few decades. Currently, technology education as an integral part of general education is offered in all over the world including Africa, America, Asia, and Europe (Layton, 1994; Sarborough, 1991).
Justifications of technology education differ from one country to another. National economic concerns and the need to understand and control the influence of technology on humans and society have been the primary motives for change from vocational to general technology education. Recognition of the importance of technological knowledge and capability also propels technology education into general education (Jenkins, 1994).

In spite of the fact that problem solving as goals, curriculum components, or both has been a growing interest of technology educators around the world, technological problem solving activities in schools are found in a relatively small number of countries such as Australia, Canada, New Zealand, the United Kingdom, and the United States (Chinien, Oaks, & Boutin, 1995; Hutchinson, 1986; Layton, 1994; Wright, 1993).

Historically, British technology education has placed more emphasis upon problem solving or design process than any other country (Hutchinson, 1986; Wright, 1993). Technological problem solving has its origin in the United Kingdom; the United States has adopted British technological problem solving; and others, including Australia, Canada, and New Zealand, are in the introduction phase (Hutchinson, 1987; K. F. Zuga, Personal communication, October 19, 1995).
In the United States, there is an historical tradition which dates back to John Dewey’s involvement in problem solving and technology education in the early 1900s (Britz & Richard, 1992; Doyle, 1991). Early American technology educators regarded problem solving as an important teaching-learning method for industrial arts (Foster, 1994). However, problem solving was rarely implemented in the classroom. In the 1980s, British technological problem solving was introduced to the United States by Ron Todd and Patricia Hutchinson. The introduction of British technological problem solving made many aware the importance of problem solving in technology education in the United States.

The United Kingdom and the United States have more research and implementation experiences with respect to problem solving in technology education than most countries. This study investigates and compares curriculum, implementation, and definitions of problem solving in technology education at the secondary level in these two countries to explore the effective implementation of problem solving activities in technology education.

Statement of Problem

Even though the history of technology began along with the history of human beings, only in recent years has technology
become the central focus of educators' attention. There has been a growing influence of technology on virtually every aspect of human life including social and daily life. For the purpose of meeting the needs of a technology-based society, many countries have developed a technology education based-curriculum to replace traditional industrial education, such as industrial arts in the United States and craft, design, and technology in the United Kingdom which has been vocational education oriented (Jenkins, 1994; Layton, 1994). One consistent element of these efforts has been the inclusion of technology education as an integral part of general education.

Recently, problem solving has been the focus of educators' attention, including technology education professionals. The development of problem solving skills has been perceived as a major goal, an important component of curriculum, or a primary teaching method in the field of technology education in countries such as the United Kingdom and the United States (Hutchinson, 1986; Layton, 1994; Zaner, 1987). However, the international technology education field has been in need of research on problem solving. The lack of such information represents gaps in technology educators' knowledge of problem solving in technology education.

There have been similarities and inconsistencies or confusion in defining and implementing problem solving in technology
education in the United Kingdom and the United States. Much uncertainty exists about the definition, curriculum, teaching and learning, and assessment of technological problem solving in secondary education. The problem investigated in this study was the similarities and inconsistencies of problem solving in technology education at the secondary level between the United Kingdom and the United States. A need existed to identify similarities and differences regarding the definition, curriculum, teaching and learning methods, and assessment of problem solving in technology education for secondary students.

**Purpose of the Study**

The purpose of this study was to investigate and compare problem solving in technology education for secondary students in the United Kingdom and the United States by identifying: (a) the way in which problem solving is defined, (b) curriculum of problem solving including goals and content, (c) implementation of problem solving such as instructional strategies and teacher’s role, (d) assessment methods of problem solving competence, and (e) proportion of problem solving in technology education at the secondary level.
Research Questions

To investigate how problem solving in secondary technology education is perceived by technology educators in the United Kingdom and the United States, the following questions were addressed.

1. How is problem solving in technology education defined by technology educators in the United Kingdom and the United States?

2. How is curriculum perceived in conjunction with problem solving in technology education at the secondary level by technology educators in the United Kingdom and the United States?
   a. What is the perception of goals that could be included in problem solving in technology education at the secondary level?
   b. What is the perception of curriculum content that could be included in technological problem solving at the secondary level?

3. How is the implementation of problem solving in technology education for secondary students perceived in the United Kingdom and the United States?
   a. What kind of instructional strategies are appropriate for problem solving in technology education at the secondary level?
b. What is the teacher's role in problem solving instruction in technology education programs for secondary students?

4. What kind of methods are appropriate to assess problem solving competence in technology education for secondary students in the United Kingdom and the United States?

5. What is an appropriate proportion of problem solving in technology education programs at the secondary level?

Significance of the Study

The rapid changes and advancement of technology in the world have made teaching facts impractical. In this changing technological society, problem solving is more important than ever. In recent times, problem solving has entered the spotlight in not only technology education but also in the field of education. The emergence of problem solving as an essential component of technology education is a significant curriculum development of recent years. However, there is much uncertainty about the definition, implementation, curriculum, and evaluation of problem solving in the field of technology education.

In spite of the fact that problem solving is often mentioned as a major goal or the primary teaching method of technology education, the research base of technological problem solving is
very weak (McCrorry, 1987; Zuga, 1994). Technology educators have not done much research on problem solving. Zuga (1994) states:

There is an indication that problem solving is not being done, even by teachers who have been recognized as outstanding. Teacher educators are just beginning to identify what should be done in their programs with respect to using problem solving as a teaching method. In addition, only a few researchers have begun to evaluate the efficacy of problem solving as an instructional method. (p.46)

Therefore, no patterns of information exist about how to use problem solving in the field of technology education.

This study provides the field of technology education needed information related to technological problem solving which is perceived as a major goal, a teaching method or both of technology education programs. The study is expected to facilitate the efforts of curriculum designers, researchers, technology teachers, and technology teacher educators. This study identifies the definition, curriculum, implementation and assessment of problem solving in secondary technology education in the United Kingdom and the United States to explore the best curriculum, teaching-learning methods, and evaluation methods of problem solving in technology education programs. The findings of this study will help reduce uncertainty during the developing revising, and implementing of problem solving in the field of international technology education.
Definition of Terms

Technology Education

"Technology education is a school subject designed to develop technological literacy" (International Technology Education Association, 1996, p. 29). The scope and nature of technology education varies from one country to another. Something in common in technology education is that technology education is an educational program which focuses on the study of concepts and the influence of technology, critical consumerism, career exploration, intellectual process and the wise use of technology rather than concern with technology development and particular arts of industry (Hutchinson, 1987; Zuga, 1989). In this study, technology education is defined as a integral part of general education that teaches technology at the secondary school level for the purpose of helping students to achieve appropriate levels of technological knowledge and capability.

Problem Solving

A problem refers to "an unsettled matter demanding solution or decision and requiring usually considerable thought or skill for its proper solutions or decision"; or "an issue marked by usually considerable difficulty, uncertainty, or doubt with regard to its proper settlement" (Gove et al., 1986, p. 1807). For the purpose of this study, problem solving is defined as a task-oriented process that students pursue practicable solutions
or decisions to a given unsettled situation or matter requiring considerable thought or skill for its proper solutions or decisions in educational purpose.

**Technology Educator**

An educator refers to "a person whose work is to educate others; a specialist in the science of education; an authority on educational problem, theories, and methods" (McKechnie, 1962, p. 577). A technology educator is a person who teaches technology education, a specialist in the field of technology education, or authority on problems, theories, and methods of technology education. For the purpose of the study, a technology educator is defined as a university professor in the field of design and technology education in the United Kingdom or technology education in the United States; a specialist in the technology education field; or an authority on curriculum, instruction, or other aspects of technology education.

**Goal**

A goal refers to "the end toward which effort is directed" (Merrian-Webster's collegiate dictionary, 1994, p. 499). For the purpose of the study, a goal is defined as a statement of intent or aspiration which a teacher wishes to achieve through the interaction with the learner.
Curriculum Content
Curriculum refers to "the whole body of courses offered by an educational institution or one of its branches; any particular body of courses set for various majors"; or "all planned school activities including besides courses of study organized play, athletics, dramatics, clubs, and home-room program" (Gove et al., 1986, p. 557). Content refers to "something contained; the topics or matter treated in a written work"; or "the matter dealt with in a field of study" (Merrian-Webster's collegiate dictionary, 1994, p. 250). For the purpose of this study, curriculum content is defined as a topic or matter of any particular body of course that should be covered to attain goals of the course.

Instructional Strategy
A strategy refers to "careful plan or method or a clever stratagem; the art of devising or employing plans or stratagems toward a goal" (Gove et al., 1986, p. 2256). For the purpose of this study, an instructional strategy is defined as a teaching plan or method which the teacher designs and uses in order to attain goals or objectives of instruction effectively.

Teacher's Role
Role refers to "a socially expected behavior pattern usually determined by an individual's status in a particular society" (Merrian-Webster's collegiate dictionary, 1994, p. 1014). In
this study, teacher's role is defined as an educationally expected activity or behavior pattern of the teacher determined by a teaching-learning condition in order to instruct efficiently and attain instructional objectives effectively.

Assessment Method

An assessment refers to "an attempt to measure the performance of something or somebody" (Ellington & Harris, 1986, p. 15). In this study, an assessment method is defined as a method of an endeavor which measures secondary student performance.

Assumptions and Limitations of the Study

The intent of the study was to provide a clear understanding and comparison of problem solving in technology education at the secondary level in the United Kingdom and the United States through the opinions expressed by technology educators recognized as having high levels of relevant expertise. Therefore, the data collected for the study were reflective of the expertise of the purposively selected study participants.

In the study, it was assumed that the review of literature, participation in international conferences, and opinions of technology educators selected were sufficient to identify experts of problem solving in secondary technology education. It was also assumed that the experts selected for the study had
high levels of expertise in curriculum, instruction, and others of technological problem solving in the secondary education in their countries and provided responses indicative of that expertise.
CHAPTER 2

REVIEW OF LITERATURE

Education shall aim at, under the great ideal of benefits for all humankind, assisting all people in perfecting individual capability, developing the ability for independent life, and acquiring citizenship qualifications needed to serve for the democratic development of the nation and for the realization of human co-prosperity. (Article 1 of The Education Law of Korea Republic)

A review of literature on technology education around the world illustrates that technology education as an integral part of general education is spreading worldwide more than ever. In addition, there has been a growing interest in problem solving as a curriculum organizer or teaching-learning method in the field of technology education in international society. The review also shows that the technology education field is in need of more research about the nature and use of problem solving. Relatively, more research and implementation experiences of technological problem solving could be found in the United Kingdom and the United States than in any other countries.

This literature review contains three major topics closely relate to the research problems and questions. Included in the
review of literature are the following: (a) An examination of the current status of international technology education and technological problem solving in secondary education including the United Kingdom and the United States, (b) the nature of problem solving including definition and process, and (c) the implementation of problem solving in education with respect to curriculum, the instructional strategy, role of teacher, and assessment method.

**International Technology Education and Problem Solving**

As a result of a significant curriculum development for the last few decades, the inclusion of technology education into the school curriculum to meet the need of technology-based society, technology education as a integral part of general education has spread all over the world.

The international survey by the United Nations Educational, Scientific and Cultural Organization (UNESCO) reveals that technology education as an integral part of general education is offered not only in developed but also developing countries, including Argentina, Belgium, Egypt, Finland, France, Germany, Ghana, Mauritius, Morocco, Tanzania, Tunisia, United Kingdom, United States, Uruguay, and Zaire (Sarborough, 1991).
Asian countries also have offered technology education in their schools as a separate subject in Korea and Taiwan and a part of an integrated subject in Japan for over a quarter of a century. The main purpose of technology education programs in these countries has been to improve students' technological understanding and capability (Fang, 1994; Lux & Lee, 1979; Murata & Stern, 1993).

Along with diverse justifications of technology education from country to country, there have been various viewpoints and approaches to technology education. de Vries (1994) analyzed and divided the following various approaches to technology education in the world: (a) the craft-oriented approach, (b) the industrial production-oriented approach, (c) the high-tech approach, (d) the applied approach, (e) the general technological concepts approach, (f) the design approach, (g) the key competence approach, and (h) the science, technology, society approach.

Technology education and technological problem solving in the United Kingdom and the United States are explained in this chapter.

American Technology Education and Problem Solving
American technology education is in transition from industrial arts to technology education. Technology education is the new
name for industrial arts in the United States. The roots of technology education are in manual training which had both a vocation and general education purpose in the late nineteenth century.

In late 1900s, there has been consensus among American educators in which technology education is an educational program focusing on the study of concepts, principles, and effects of technology rather than concerned with the particular arts of industry. In the field of technology education, technology has been widely perceived as "a body of knowledge and the systematic application of resources to produce outcomes in response to human needs and wants" (Savage & Sterry, 1990, p.7).

Goals of early industrial arts were related to career exploration and vocation, consumerism, and skill development in a pre-vocational view. On the other hand, recent technology education goals emphasize the study of industry and technology, critical consumerism, and the development of intellectual process and interpersonal skills in a general educational view (White, 1990; Zuga, 1989).

Technology educators in the United States insist that technology education should be a part of general education regardless of the occupation to be pursued. The primary goals of recent technology education in the United States are related to
technological literacy. A good example of these goals is shown in Savage and Sterry’s report (1990):

The goals of the technology education program are to provide technologically literate individuals who are capable of:
1. Utilizing technology to solve problems or meet opportunities to satisfy human needs and wants.
2. Recognizing that problems and opportunities exist that relate to and often can be addressed by technology.
3. Identifying, selecting, and, using resources within to create technology for human purpose.
4. Identifying, selecting and efficiently using appropriate technological knowledge, resources, and processes to satisfy human wants and needs.
5. Evaluating technological ventures according to their positive and negative, planned and unplanned, and immediate and delayed consequences. (p. 27)

 Typically, the subject matter of technology education in the United States is mainly drawn from the technological system areas of communication, manufacturing, transportation, and construction (White, 1990). In general, “hands-on” activities, problem solving skills, and increasing technological literacy are emphasized in technology education programs (White, 1990). Technological awareness is emphasized at the elementary school level while exploratory, broad and fundamental, and focused on understanding of nature are stressed at the middle/junior high school level. At the high school level, knowledge of various technological systems, wise decision making, and problem solving are emphasized (Kozak & Robb, 1991).

In the United States, there is an historical tradition which dates back to John Dewey’s involvement in problem solving and
technology education in the early 1900s (Britz & Richard, 1992; Doyle, 1991). The American philosopher and educator, John Dewey, was very emphatic on the importance of the problem solving in education as indispensable resources of further inquiry or learning as follows:

The accumulation and acquisition of information for purpose of reproduction in recitation and examination is made too much of. 'Knowledge,' in the sense of information, means the working capital, the indispensable resources of further inquiry, of finding out or learning, more things. Frequently, it is treated as an end in itself, and then the goal becomes to heap it up and display it when called for. This static, cold-storage ideal of knowledge is inimical to educative development. It not only lets occasions for thinking go unused, but it swamps thinking. No one could construct a house on ground cluttered with miscellaneous junk. Pupils who have stored their 'minds' with all kinds of material which they have never put to intellectual uses are sure to be hampered when they try to think. They have no practice in selecting what is appropriate, and no criterion to go by; everything is on the same dead static level. (1966, p.158)

Early United States technology educators regarded problem solving as an important teaching-learning method for industrial arts. However, problem solving rarely was implemented in classrooms in practice by the 1980s. Foster points out the position of problem solving in early United States technology education:

Although problem-solving may historically have became prominent in industrial arts literature later than other emphases of industrial arts education, Dopp (1902), Bonser (1914), Marot (1918), and Griffith (1920) all considered the topic to be a methodology integral to industrial arts in the first two decades of this century. At the end of the next decades, Sotzin listed 'problem-solving' as being among the 'claims and recommendations' most often made by
educators for industrial arts. But claims and recommendations in theory do not always correlate to results in practice. Browning and Greenwald recently described problem solving as 'a goal never lived up to in many industrial arts programs' (1994, P. 23).


Traditionally, problem solving has not been included in the curriculum at the elementary and secondary level. At most problem solving could be found in the curriculum of restrictive areas including mathematics and science in elementary and secondary education (Britz & Richard, 1992, p. 11; Waetjen, 1989, p. 5).

Recently, problem solving has been spread to every subject of the elementary and secondary school curriculum as an important curriculum component or major goal (Britz & Richard, 1992; Drum & Wells, 1984). This phenomena is due to the change of
perception that developing problem solving skills is more important than learning specific facts and tool skills and it is an indispensable resource of further inquiry or learning to meet societal changes.

Winek and Borchers (1993) provide more concrete reasons why problem solving should be included in the educational curricula:

1. Problem-solving gives us a means, 'to create a climate of and receptivity to technological innovation' [Waetjen, 1989]. Students who understand new technical knowledge are able to use it to solve technical problems in new and unique ways.
2. Problem solving is a needed higher order of thinking skill. It is the pinnacle of human thinking skills with no other cognitive skill as complex [Lavoie, 1991; Stinespring, 1991; Waetjen, 1989]. Technological problem solving allows students to draw on their past knowledge, combine it with new knowledge and use assimilation and evaluative skills to solve a problem. With this skill mastered, the world becomes exciting, challenging and full of opportunity. Without problem solving skills, the world can be very intimidating.
3. Problem solving helps to apply the wealth of information already discovered. An example of applying new technology was the use of integrated circuits and other electronic inventions to develop the first personal computer known as the Apple. (p. 23)

Technology for All Americans, (1996) the current project of the International Technology Education Association for developing national standards of technology education for K through 12 graders, reveals the current tendency- a growing and strong interest in problem solving in technology education in the United States. The project suggests technological literacy, which is "the ability to use, manage, and understand
technology," (International Technology Education Association, 1996, p. 6) as a target of technology education. The project shows that the development of technological problem solving skills is being watched with keen interest among technology educators in the United States. The following statement shows that problem solving is regarded as not a learning method or strategy but a goal of technology education:

Technologically literate persons are capable problem solvers who consider technological issues from different points of view and in relationship to a variety of contexts. They acknowledge that the solution to one problem often creates other issues and problems. They also understand that solutions often involve trade-offs, which necessitate accepting less of one quality in order to gain more of another. Technology literate people use a strong systems-oriented approach to thinking about and solving technological problems. Technologically literate persons can identify appropriate solutions and assess and forecast the results of implementing the chosen solution. As managers of technology, they consider the impacts of each alternative, and determine which is the most appropriate course of action for the situation. (p. 11)

British Technology Education and Problem Solving

British technology education has evolved over time with priority given to problem solving, the design process, or both (de Vries, 1994; Hutchinson, 1987). Handicraft is considered as a major forerunner of the technology education program in the United Kingdom (Hutchinson, 1987). British technology in education programs after World War II can be divided into the following major steps: Craftwork; craft, design and technology; and the national curriculum.
First, craftwork (1945-1969) was a series of separate studies in woodworking, metalworking, and technical drawing. "Using tools to build projects" was emphasized in this program (Wright, 1993, p. 61). In the second craft, design and technology step (1970-1989), design was added to "the making emphasis of the craftwork program. Starting in 1975 problem solving was fused into the program that added evaluation to the designing/making emphasis of craft, design and technology[sic]" (Wright, 1993, p. 61).

More recently, the British government developed a new technology education program so called 'design and technology education' as one of the subjects in the national curriculum. The national curriculum in the United Kingdom is "actually the curriculum for England and Wales. The other two countries that make up the United Kingdom, Scotland and Northern Ireland, have their own curriculums with a uniquely different type of technology education" (Wright, 1993, p. 60). An analysis by Wright (1993) elucidates technology education in the national curriculum:

The National Curriculum is a mandatory program for all state primary and secondary schools. It includes technology as a foundation (core) subject 'which requires pupils to apply knowledge to solve practical problems.' The subject of technology education . . . merged two separate subjects that were in the schools: craft, design and technology[sic] and home economics. Technology is divided into two components: design and technology capability and information technology capability. Information technology is seen as cross-curricular and is recommended to be taught as an integral part of all foundation subjects including technology. Design and technology is expected to be taught through themes and
projects in the primary school and as a separate subject in the secondary school. Design and technology instruction is couched within home, school, recreation, community, and business and industry contexts and explores an interrelationship between environments, artifacts, and system. Design and technology includes four basic areas: construction materials, food, textiles, and graphic media. Each of these areas focus on four attainment targets which are the major organizers of the curriculum (p. 60-61).

The British technology education program has emphasized problem solving, the design approach or both while others focus on content (Wright, 1993). There has been more theory and experiences on technological problem solving in the United Kingdom and the United States than in any other countries.

**Nature of Problem Solving**

Problem solving activity has been a part of the history of human beings. Early consideration of problem solving can be found in ancient Greece. One of the oldest of basic tenets of learning and problem solving is "associationism which can be traced back to Aristotle and his laws of learning and mental life which held that there were ideas and associations (or connections) between them" (Waetjen, 1989, p. 4). Another good example of problem solving activity can be also founded in the middle ages. The Italian artist, scientist, and technologist, Leonardo da Vinci used knowledge, which he learned by observation and analyzing, in solving problems of painting, building, and engineering (Breckon & Prest, 1983; Hutchinson & Karsnitz, 1994).
Although inquiry into problem solving has been with human society for a long time, it was not until the early twentieth century that speculation was joined with education. Much has been discussed about the nature of problem solving in both British and American education during past few decades. However, in education, there has been controversy and inconsistency about nature of problem solving, including the definition and processes. The need and nature of problem solving concerning its definition and process is discussed in this part.

Needs of problem solving
The rapidly evolving world today is forcing educators to change school curriculum to meet social changes. In this time of educational change, problem solving has come into the spotlight in most fields of education. With respect to changes in the societal and educational environments, the need for problem solving was clearly stated by Drum and Wells (1984) as follows:

with the explosion of knowledge that has occurred within the past thirty years, the ability to solve problems has become more and more critical. It is not possible to teach children all the accumulated knowledge they may need, and the answers to the problems of today may not be appropriate for the problems of tomorrow. Children must learn to search for information, to formulate answers, and to create innovative solutions to new problems. They must learn to be problem solvers. (p. 1)

During the 1980s, several reports in the United States, including A Nation at Risk: The Imperative for Educational
Reform, insisted on educational reform to meet the changes and problems facing modern society. The report, *Educating Americans for the 21st Century*, of the National Science Board Commission on Precollege Education in Mathematics, Science and Technology (1983) emphasized developing problem solving skills with respect to technological and educational changes as follows:

We must return to basics, but the 'basics' of the 21st century are not only reading, writing, and arithmetic. They include communication and higher problem-solving skills, and scientific and technological literacy—the thinking tools that allow us to understand the technological world around us. These new basics are needed by all students . . . More importantly, we indicate the kinds of problem solving insight and skills that must be provided. (pp. v, xi)

More recently, two reports of the Secretary's Commission on Achieving Necessary Skills also force educators to change school curriculum by emphasizing higher order thinking skills to meet the rapidly changing society. In these reports, problem solving skills were identified and recommended as an important readiness which "competent workers in the high-performance workplace need" (1992, p. 6; see also, 1991).

Development of computer technology and expanding computer use provides educators with another reason for the need for problem solving. Rubinstein and Firstenberg (1987) emphasize the importance of problem solving for "nonprogrammable activities":

As the computer increasingly assumes programmable functions, an increasing share of human thinking and
problem solving must shift to nonprogrammable activities. These activities include the finding of appropriate problems, the identification of goals in the contexts of human values, the use of strategies in the acquisition of information that enhance retrieval, the representation of problems and the constructions of models from complementary points of view or frame of reference, and the identification of reasonable goals and answer that will do when the 'best' answer cannot be obtained within a reasonable time at the cost of reasonable effort or when it cannot be recognized when attained. (p. 34)

Definition of Problem Solving

There might be said to be two major sources of the concern with problem solving activities. One is a work of the designer and technological researcher in technology and industry. The other is a learning method for child-centeredness in education (Down, 1986). In education, problem solving usually has been associated with thinking skills and perceived as a good way to teach thinking skills (Down, 1986; Greenfield, 1987). Greenfield (1987) states:

the teaching of thinking is equivalent to the teaching of problem solving, but conflicts arise as to the best way of doing it. The difficulty stems in part from differential concepts and different meanings attached to the term problem solving as well as from consideration of the differences among individual problem solvers and among individual problems. (p. 5)

In the field of technology education, problem solving often has joined forces with design. As a matter of fact, there has been an ambiguity between the two terms, design and problem solving. Sometimes, design is perceived as "a special instance of problem solving in which playfulness and guided thought predominate"
(Hutchinson, 1987, p. 20). DeLuca's analysis takes this point of view. He (1992) regards the design process as an one of five problem solving processes such as (a) troubleshooting or debugging, (b) scientific process, (c) design process, (d) research and development, and (e) project management.

On the other hand, the term design often is used roughly equally to problem solving in the field. This point of view is shown in analysis of Todd, Todd and McCrory (1996), that is, design is to solve practical problems that arise from a real situation. Eggleston (1992) also thinks of design as problem solving. He explains the relationship between design and problem solving by stating "the design process" is "the process of problem solving" (p. 18).

Hutchinson and Karsnitz explain the relationship between design and problem solving in a similar way, problem solving through design process or designing through problem solving. They (1994) define design and explain the relationship between designing and problem solving as follows:

Design is the planned process of change. Instead of something changing by accident, design demands that we plan change so that we end up with the results we want. It also means that we attempt to minimize trade-offs and control risk . . . Creating solutions to problems involves the process of designing. Design is a broad term that is often associated with artistic expression, but it is best thought of as a thinking process involving planning with intention and purpose . . . design describes the process of developing solutions to problems. (p. 18)
Regarding design as problem solving, Eggleston (1992) explains problem solving as follows:

problem solving . . . begins with a detailed preliminary identification of a problem and a diagnosis of needs that have to be met by a solution, and goes through a series of stages in which various solutions are conceived, explored and evaluated until an optimum answer is found that appears to satisfy the necessary criteria as fully as possible within limits and opportunities available. (p. 18)

Woods (1987) regards problem solving as a mental process as follows:

Problem solving is the mental process that we use to arrive at a 'best' answer to an unknown or some decision, subject to a set of constraints. The problem situation is not one that has been encountered before: we cannot recall from memory a procedure or a solution from past experience. We have to struggle to obtain a 'best' answer. (p. 55)

Doyle also conceives problem solving as a process, which pursues "feasible solutions to a problem, challenge, or opportunity" (1991, p. 12).

These diversified approaches and definitions of problem solving and intertwining of design and problem solving have yielded diverse analyses of process and implementation of problem solving in education. In short, the essence of problem solving is the application of knowledge and process that leads to a solution of a problem.
Process of Problem Solving

In relation to the study of problem solving, much has been done about its process than any other facts. One of the early studies of problem solving process was done by Dewey. He investigated the process of thought and analyzed the five phases of reflective thought which can be applied to problem solving:

(1) suggestions, in which the mind leaps forward to a possible solution; (2) an intellectualization of the difficulty or perplexity that has been felt (directly experienced) into a problem to be solved, a question for which the answer must be sought; (3) the use of one suggestion after another as a leading idea, or hypothesis, to initiate and guide observation and other operations in collection of factual material; (4) the mental elaboration of the idea or supposition as an idea or supposition (reasoning, in the sense in which reasoning is a part, not the whole, of inference); and (5) testing the hypothesis by overt or imaginative action. (1960, p. 107)

Another analysis of the process is offered by a mathematics educator, Polya (1948). His analysis is a result of his own efforts to try to understand and explain his and his students' motives and procedures for solving problems. The following four steps of problem solving by Polya, which are composed of list of questions, were designed to help both teachers who are trying to develop their students' abilities and students who are trying to develop their ability to solve problems on their own.
The first step is understanding the problem which can be started with the questions: "What is the unknown? What are the data? What is the condition? . . . Is it possible to satisfy the condition?" (Polya, 1948, p. 6). The second step, devising a plan, also works best with the following questions:

1. Do you know a related problem? Look at the unknown! And try to think of a familiar problem having the same or a similar unknown.
2. Here is a problem related to yours and solved before. Could you use it? . . . Could you restate the problem?
3. If you cannot solve the proposed problem, try to solve first some related problem . . . Did you use all the data? Did you use the whole condition? (p. 9)

A couple of points are suggested for the third step, carrying out the plan: Carry out your plan of the solution. "check each step . . . Can you see clearly that the step is correct? . . . Can you also prove that the step is correct?" (pp. 12-13) The last step, looking back, has also several questions: "Can you check the result? Can you check the argument? . . . Can you derive the result differently? . . . Can you see it at a glance? . . . Can you use the result, or the method, for some other problem?" (pp. 14-15)

Guessing correctly and luck play a significant role in Polya’s analysis. Polya’s direction contributed a lot to problem solving not only in the mathematics but also in the other educational fields by adapting and using “an experience-based heuristic designed to understand mental operations that is particularly
useful for and relevant to problem of the 'problem-to-find' variety” (Greenfield, 1987, p. 12).

Rubinstein’s (1975) analysis of problem solving offers another pattern of problem solving processes consisting of six steps: Get the total picture, withhold your judgment, use models, change representation, ask the right questions, and have a will to doubt. He further suggests six paths that can be used to generate a solution: work backward, generalize or specialize, explore directions when they appear plausible, use stable substructures (modules) in the solution process, use analogies and metaphors, and be guided by emotional signs of success.

Britz and Richard (1992) suggested four sequenced steps as components of problem solving model. They emphasize that students can become skillful at problem solving by understanding and using the following sequenced steps: (a) identify the problem, (b) discuss solutions, (c) choose a solution and try it out, and (d) evaluate the situation (p. 41).

A variety of processes of problem solving for technology education are also discussed in the field of education in the United States and the United Kingdom. Breckon and Prest (1983) split the process of designing, which can be substituted for problem solving, into the following seven steps to help understand the process: (a) the need, (b) the design brief, (c)
thinking and researching, (d) developing ideas, (e) planning, (f) realizing, and (g) testing and evaluating. Another similar process of design consisting of six steps was proposed by Barlex and Kimbell (1986): research, exploring ideas, developing ideas, planning the making, making, and evaluation.

Waetjen (1989) provides a deeper analysis of problem solving process for us on the basis of his belief that the role of problem solving can be realized best in technology education. His process conceived for use in technology education laboratory settings consists of following six steps: (a) define the problem, (b) re-form the problem, (c) isolate the solution, (d) implement the plan, (e) restructure the plan, and (f) synthesize the solution. Figure 1 shows that five steps are discreetly related each other in the whole process. (See Figure 1)
Dunn (1991) also offers a more specific explanation of the design process consisting of seven steps:

1. Brief or problem: A short statement indicating the intent of what to design and make.
2. Investigation: This stage carried out by thinking and researching the problems involved. This stage consists of three steps: functions, questions and comments, and research.

Figure 1. Waetjen’s technological problem solving process.
(Waetjen, 1989, p. 9)
3. Ideas: Various ideas and possible solutions are considered in sketch form or in model form together with explanatory notes where needed.

4. Develop idea(s): The most feasible ideas and solutions are considered in more detail, they can be completely new ideas or new version of old ideas. The main things you need to decide on are the materials to use, the main dimensions, possible joints and construction methods, possible surface finishes, and how the parts can be made.

5. Working drawing or model: This has to provide enough information to enable to someone else to make chosen ideas.

6. Make: The product is made with improvements to the design if needed.

7. Test: The product made is tested to see if it does its job successfully. If not, you may need to make some small alterations or even start again (p. 5).

Eggleston introduces the design process adopted by the Schools Council Project on Design and Craft Education in the United Kingdom. This design process shown in Figure 2 illustrates "detailed and analytical process of inquiry [sic] that leads to the achievement of design . . . and the meaningful social context and range of participation within which the process is undertaken" (Eggleston, 1992, p. 19). (See Figure 2)
Figure 2. Design process of Design and Craft Education Project
(Eggleston, 1992, p. 20)
Hutchinson and Karsnitz (1994) give credence to the design process "as a guide to help make problem solving in technology more effective" (1994, p. 18). It consists of following sequential steps:

1. Identifying problems and opportunity as analyzing a real-world situation,
2. Framing a design brief as problem clarification and specification,
3. Research and investigation as information gathering,
4. Generation of alternative solutions,
5. Choosing the best solution,
6. Developmental work,
7. Modeling and prototyping as construction,
8. Testing and evaluating.

They give emphasis on the fact that designing and problem solving is a non-linear process and "more like switching back and forth between a thinking- questioning- evaluating mode and an acting- doing mode. These modes have been called the 'active' and 'reflective' phase of design, and you are constantly moving between the two." Figure 3 shows the interrelationship of steps in of their design loop which "provides a structure for thinking and doing, which is the essence of technological activity" (1994, p. 18). (See Figure 3)
Another design process, IDEATE Design loop, is offered by Todd, Todd, and McCrory. The design loop is intended to provide the framework on which students can logically and in an organized manner solve technological problems. This loop shown in Figure 4 consists of the following six steps (1996):

Figure 3. Hutchinson and Karsnitz’s Design Loop. (Hutchinson & Karsnitz, 1994, p. 19)
1. Identify and define the problem (investigating needs and opportunities)
2. Developing the design brief (clarifying the results you want to achieve)
3. Explore possible alternatives (searching for solutions and information)
4. Accumulate and assess the alternative (developing and choosing the best solution)
5. Try out the best solution (experimenting and developing solutions, models, and prototypes)
6. Evaluate the results (testing the solution and assessing the process) (p. 4)

Figure 4. The IDEATE Design Loop. (Todd, Todd, & McCrory, 1996, p. 4)

DeLuca (1992) synthesized a variety of the problem solving processes that have application in technology education by classifying them as follows:
1. Troubleshooting or debugging: isolate the problem, identify possible causes, test, implements solution, and test solution.
2. Scientific process: observation, develop hypothesis, experimentation, and draw conclusions.
3. Design process: Ideation or brainstorm, identify possible, prototype, and finalize design.
4. Research and development: conceptualize the project, select research procedure, finalize research design, develop proposal, conduct research, analyzed result, report result, and evaluate research project.
5. Project management: identify project goals, identify tasks to reach the goals, develop a plan to accomplish the tasks, implement the plan, and evaluate the plan. (p. 26)

There are many legitimate analysis and models for design, problem solving, or both that can be applied to an educational program. While British technology educators have been interested in design process, American technology educators have focused on the process of technological problem solving. Something common in the analysis and models discussed in this part is that they are complicated and perceived as not a linear process. Most of the design and problem solving processes have the common components such as (a) good problem solving statements, (b) research and development, (c) testing of solutions, (d) and evaluation.
Curriculum of Problem Solving in Education

Curriculum, including goals and objectives, and content of problem solving in the field of education is different from country to country. Problem solving has been perceived as a good way to foster thinking skills both in the United Kingdom and the United States. In the field of technology education, manufacturing has used design or problem solving as content more than construction, energy and power, and communication in the two countries. More specific curriculum of problem solving in the United States and British educational fields is discussed in this part.

Goals of problem solving in education

Draze gives emphasis to problem solving in early childhood education. He points out that problem solving can provide children with the following skills:

1. The ability to read or hear a passage and select relevant information.
2. The ability to summarize information that is presented.
3. The ability to analyze a social situation.
4. The ability to think creatively to generate a large number of possibilities.
5. The ability to think creatively to generate a variety of situations
6. The ability to evaluate options based on given criteria.
7. The ability to apply creative thinking to a variety of situations.
8. The ability to plan activities that are relevant to accomplishing a goal.
9. The ability to make inferences. (1986, p. 5)

Bagshaw, Branson, Brotherhood, Hindhaugh, Morecroft, Robotham, Smith, and Wall point out the following goals of problem solving in technology education with emphasis on open-ended activities: (a) evaluative activity, (b) research and investigation, (c) designing, (d) planning and making, and (d) working either as an individual or as part of a group (1991, p. 25). Emphasis on evaluation is worth special mention in their goals.

Wicklein (1993) proposed comprehensive goals and detailed objectives that go with each goal for a process-based technology education curriculum. With regard to problem solving, he suggested the following as goals of technological problem solving: (a) Develop critical thinking skills related to technology education, (b) develop creative abilities to solve problems, (c) research and develop ideas related to solving problems, (d) develop the ability to manage the problem solving process, and (e) apply systematic approaches to solve problems (p. 76).
Breckon, Finney and Fowler (1986b) propose detailed goals of a problem solving course for the middle school students as follows:

1. To provide situations which encourage pupils to use their intellectual and practical skills to solve problems, by research and analysis, producing ideas choosing and developing a viable solution and then making it, using the appropriate materials and technologies.

2. To enable pupils to test the validity of their solutions by providing them with the skills to make and evaluate the product.

3. To establish an understanding of working materials and systems in a safe manner.

4. To establish an understanding of basic technological concepts and their application.

5. To develop the ability to communicate designing, making and evaluating by appropriate methods, including verbal, visual, written and numerical means.

6. To provide opportunity for the pupils to express themselves creatively.

7. To provide opportunity for application of concepts learned in other subject areas, e.g. mathematics, science and art.

8. To develop in pupils valuable attributes through the course’s demand for initiative, ingenuity, resourcefulness, self-involvement and motivation, co-operation, patience, sensitivity and commitment.
10. To initiate an appreciation of the value of aesthetics in the designing and making of products.
11. To encourage a discerning attitude towards personal standards of work.
12. To encourage a discerning attitude towards products we use in our everyday life.
13. To encourage an interest in manufacturing industry. (p. 4).

Curriculum Content of Problem Solving in Technology Education

There are a variety of ways to organize the curriculum content of problem solving as an integral part of technology education at the secondary level. For selecting the content of a design or problem solving course in technology education at the early secondary level, Kimbell (1982) recommends five major areas of subject matter that should be dealt with as follows:

1. the properties of the normal range of materials such as wood, metal, and plastics;
2. the tools and process which may be applied to these materials;
3. physical/technological phenomena;
4. aesthetic/visual phenomena;
5. the means of visual communication. (p. 38)

Breckon, Finney and Fowler (1986b) suggest more specific and detailed content that needs to be covered in design and technology education which can be applied to problem solving in technology education for middle school students:
1. Designing such as methods of researching, analyzing and evaluating problems and creating.
2. Graphics such as freehand sketching, isometric and 2-point perspective, orthographic sketch form, exploded views, flow diagrams, use of color, templates, modeling and presentation techniques.

3. Visual element of design including line and symmetry, form and shape, color, design in nature and texture.

5. General and specific safety with respect to relevant techniques and process.

6. Materials
   (a) Metal, plastic, wood: source, properties, and uses.
   (b) Marking out: templates, parallel and 90° to the material and centers of holes and circles.
   (c) Cutting and shaping: sawing, filing, drilling, shearing, paring and simple machining.
   (d) Deforming and reforming: laminating, line bending, and 3D forming metal and plastics.
   (e) Joining and constructions: screws, nails, nuts and bolts, rivets, soft and hard soldering, adhesives, box and frame constructions.
   (f) Finishing techniques and presentation of project work.

7. Control systems
   (a) Mechanisms: levers, linkages, pulleys, gears and cams.
   (b) Structural: forces, beams and bending, and stabilizing structures.
   (c) Electronics: component recognition, electronics principles, modeling circuits, constructional techniques,
simple switching, use of input and output devices, transistors and integrated circuits.

8. Energy: Sources and forms, storage, conversion and applications. (p. 5)

DeLuca (1992) illustrates a variety of problem solving activities implemented in technology education identified by technology teachers surveyed. Table 1 shows the activities ranked by frequency of employment by the teachers. These activities for secondary technology education programs include diversified activities such as bridge building, metric 500, mass production, robotics, paper tower, manufacturing a prototype, egg drop, paper car, house framing model, transportation modes, paper airline, chair design, sculpture and carving, hydraulic robot, ping golf, car builder, paper bridge, container design, and CAD activity.
<table>
<thead>
<tr>
<th>Rank</th>
<th>Activity</th>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bridge building</td>
<td>8-12</td>
<td>Apply knowledge of forces and principles of structural design to design and test a model bridge.</td>
</tr>
<tr>
<td>2</td>
<td>Metric 500 Mass</td>
<td>8-12</td>
<td>Design and build a CO2 car for competition.</td>
</tr>
<tr>
<td>3</td>
<td>Mass production</td>
<td>9-12</td>
<td>Develop procedure list, design jigs and fixtures, set up assembly line, produce, and sell products.</td>
</tr>
<tr>
<td>3</td>
<td>Robotics</td>
<td>10-12</td>
<td>Design a need for robotics in an industrial setting.</td>
</tr>
<tr>
<td>5</td>
<td>Paper tower Manuf.</td>
<td>7-12</td>
<td>Build a free standing tower using 18&quot; of masking tape and a piece of paper.</td>
</tr>
<tr>
<td>5</td>
<td>Manuf. prototype</td>
<td>10-12</td>
<td>Use the design process to develop and test a mass production product prototype.</td>
</tr>
<tr>
<td>5</td>
<td>Egg drop</td>
<td>9-12</td>
<td>Design a package/vehicle that will safely protect an egg when dropped from 15-20 feet.</td>
</tr>
<tr>
<td>5</td>
<td>Paper car</td>
<td>9-12</td>
<td>Design and build a paper car to race down a ramp. Design a media program to promote the product.</td>
</tr>
<tr>
<td>9</td>
<td>House framing</td>
<td>9-12</td>
<td>Construct a model of a two story house</td>
</tr>
<tr>
<td>9</td>
<td>Transportation modes</td>
<td>8-12</td>
<td>Given various parts, construct a vehicle to move cargo.</td>
</tr>
<tr>
<td>9</td>
<td>Paper airline</td>
<td>9-12</td>
<td>Design and test a paper airline for competition</td>
</tr>
<tr>
<td>9</td>
<td>Chair design</td>
<td>9-12</td>
<td>Hold 170-200 lb. person comfortably, have a seat back no less than 30&quot; from the floor, seat height of 16 to 18 inches, have no fewer than 3 separate legs, and light weight.</td>
</tr>
<tr>
<td>9</td>
<td>Sculpture &amp; carving</td>
<td>7-9</td>
<td>Apply knowledge of design elements to create a sculptured wood product.</td>
</tr>
<tr>
<td>9</td>
<td>Hydraulic Robot</td>
<td>6-8</td>
<td>Design a robot controlled by hydraulic syringe to transport different shaped objects.</td>
</tr>
<tr>
<td>9</td>
<td>Ping golf</td>
<td>7-9</td>
<td>Given material, design and build a machine to knock a ball into a hole at the end of a wooden course.</td>
</tr>
<tr>
<td>9</td>
<td>Car builder</td>
<td>8-12</td>
<td>Design a car from Car Builder software.</td>
</tr>
<tr>
<td>9</td>
<td>Paper bridge</td>
<td>8-9</td>
<td>Build and test paper bridge using given material and cost criterion.</td>
</tr>
<tr>
<td>9</td>
<td>Container design</td>
<td>9-10</td>
<td>Select a product and design a logo, package, and 30 second TV commercial.</td>
</tr>
<tr>
<td>9</td>
<td>CAD</td>
<td>9-12</td>
<td>After basic intro., Students use CAD to solve drafting problems.</td>
</tr>
</tbody>
</table>

Table 1. The Problem Solving Activities in Technology Education
Implementation of Problem Solving

With regard to the implementation of problem solving, there has been confusion between problem-based learning and teaching problem-solving methods in education. Hennessy and McCormick (1994) distinguish them as follows:

Most areas of the curriculum give pupils problems to solve as one approach to learning, where the main purpose is to help pupils understand certain concepts or ideas in the subject. The actual process of solving the problem may be unimportant . . . For those who take a learner-centered approach to education, this pedagogic strategy is very important because the learner is active and the problem makes the learning meaningful. When teaching problem-solving methods, on the other hand, the process involved in solving the problem are the focus, and understanding of concepts (conceptual knowledge) is usually of secondary importance. Those who are concerned to teach problem-solving consider it to be of more lasting relevance to pupils than content. Often they characterize problem-solving as some kind of idealized process involving the sub-process of recognizing a problem, generating and implementing a solution, and evaluating the results. Knowledge of these sub-processes (procedural knowledge) is seen as applying across a variety of areas of the curriculum. (p. 94)

A variety of ways of implementing the problem solving in education including instructional strategies, role of the teacher, and assessment of problem solving are discussed further in this part.
Instructional Strategy of Problem Solving in Education

Over the centuries, a wide variety of instructional strategies for effective teaching and learning have been developed and modified. Cruickshank and his associates have identified all available instructional strategies "that can be used to facilitate student learning and satisfaction" (Cruickshank, Bainer, & Metcalf, 1995, p. 165). Following are the twenty-nine instructional strategies that they have identified: academic games; brainstorming; case; centers of interest; colloquia; contracts; debates; demonstrations; direct instruction; discovery; discussion; drill and practice; field observation, field work, or field trips; independent study or supervised study; individualized instruction; learning modules; mastery learning; oral reports; presentation and lectures; problem solving; programmed and computer-assisted instruction; project or activity methods; protocols; recitation; role playing; simulation games; simulations; student team, pupil team, or cooperative learning; and tutoring.

Among those instructional strategies, DeLuca (1991) identified five clusters of the strategies from the most frequently used to the least frequently used by technology teachers among the methods appropriate for technology education. The cluster of instructional strategies used by technology teachers most frequently include: discussion, demonstration, experimentation,
and lecture. Individual instruction and media are the strategies listed in the second cluster. The third cluster of the strategies contains discovery, simulation, readings, and game-structured competition. The fourth cluster of the strategies consists of competency-based strategies. The cluster of the strategies used by technology teachers least frequently includes seminar, scenario, contract, case study, panel discussion, and role play. For problem solving in technology education, he (1992) recommends (a) lecture demonstration and reading for related content and prerequisites, (b) seminar, panel discussion, contract, and discovery for learning and gathering relevant information.

Problem solving activities can be divided into two kinds: individual and group activity. Many research results show group problem solving activity is more effective than individual problem solving activity in terms of the number of problems solved and speed of solution (Britz & Richard, 1992; Waetjen, 1989). It is due to the fact that many diverse ideas can be generated in group problem solving (Britz & Richard, 1992).

Rubinstein and Firstenberg (1987) suggest not to evaluate and choose among limited alternatives before sufficient time has been spent generating additional alternatives in problem solving because once a choice has been made, considering supplementary alternatives can be resisted and new choices can be prejudged.
negatively. They also suggest following heuristic guides for the successful problem solving activity:

1. Concentrate on what you can do: Focus attention on surmountable obstacles that block the way to a solution.
2. Consider implementation: Focus on both quality and acceptability for success in implementing a solution to a problem.
3. Maintain group harmony: Pay attention to feelings, both to your own feelings and to the feelings of others.
4. Be a good listener: Try not to formulate your response while you are listening to others talking.
5. Focus on what you can control: Identify actions that you can control in a problem situation, and exercise control whenever it can help you to achieve your goals.
6. Use a mixed-scanning strategy similar to that employed by master chess players. (pp. 32-34)

By stages, Jacobson and Margolin (1979) suggested the following strategies for problem solving. First, when defining a problem: (1) be specific (refer to what both partners can observe); (2) be brief; (3) express your feelings about the behavior which is the subject of the conflict. Second, when solving problems: (1) brainstorm solutions; (2) evaluate their costs and benefits to each partner and to the relationship; (3) decide on the best solution; (4) be willing to compromise; problem solving involves give-and-take. Finally, when defining and solving problems: (1) discuss only one problem at a time; (2) paraphrase what you hear your partner saying and check the accuracy of your paraphrase. They also emphasize that problem solving requires collaboration and also requires that each problem being discussed is seen as a mutual problem.
On the basis of his experience, Zaner (1987) recommend following techniques that are effective in the teaching of technological problem solving with respect to presentation of problem, introduction of problem solving process, and evaluation. First, the problem necessitates several fairly specific skills for its solution is unlikely a traditional project. Second, the "problem solving process itself must be identified and its steps must be specifically provided for in the educational activities". Finally, "evaluation must specifically evaluate the process we expect them to go through, not the product they produce" (p. 35).

For young children, William and Kamii (1986) describe three ways to encourage them to discover their ways to solve problems. The first strategy is to connect classroom activities with what is personally meaningful to them. A second way to encourage thinking is to provide opportunities for children to make decisions. The last way for supporting thinking is to encourage them to work together to solve problems.

Teacher's Role in Problem Solving

The role of teacher in problem solving activities is different from the conventional role of teacher as an information presenter. The preponderance of research results of problem solving indicates a major undertaking of the teacher is to
establish and maintain a classroom environment or circumstance that elicit a variety of thinking and encourages problem solving (Britz, 1993; Britz & Richard, 1992, DeLuca, 1992; Waetjen, 1989). For establishing and maintaining a good classroom environment or circumstance, providing appropriate time, space, and materials is necessary for in-depth learning. Britz (1993) offers a deeper explanation of those:

1. Time: Teachers can provide for problem solving by enlarging blocks of learning time during the school day. Because making choices, discussing decisions, and evaluating mistakes takes time, large time blocks best suit the problem-solving process. It is important that children know they have time to identify and solve problems.

2. Space: Projects and group meetings may require an assessment of classroom space. Moving desks and tables together facilitates communication and cooperation in the classroom. Once the teacher has observed the patterns of traffic in the classroom, equipment can be moved or eliminated to promote problem solving.

3. Materials: The open-ended materials that are needed for the construction and concrete solving of problems should be safe, durable, and varied. Well-marked storage units should be easily accessible to children, and materials should be available for ongoing exploration and manipulation. Access to a variety of materials encourages children to use materials in new and diverse ways. This freedom promotes problem solving. (Britz, 1993)

Bagshaw and his associates (1991) illustrate various roles of the teacher in problem solving instruction in technology education programs including (a) a source of relevant knowledge, (b) an expert consultant, (c) a manager of the learning circumstances, (d) a negotiator, (e) a questioning adult, (f) someone with the confidence to say that students don't know the answer, and (g) a source of opinions, attitudes and values.
Among those roles of the teachers in problem solving, the role of the teacher as a facilitator is more emphasized in problem solving instruction than any others (Winek & Borchers, 1993; Britz & Richard, 1992). Britz and Richard (1992) explain further the role of teacher as a facilitator in problem solving at the elementary level as follows:

Teacher has a central role in supporting problem solving efforts because it is the teacher who facilitates the process for children. The early childhood teacher is child-centered, creates an integrated curriculum, and strives to build reciprocal relationships with the children. In addition, the teacher makes use of the following strategies to connect the children with problem solving opportunities.

1. Create an environment that supports the children’s autonomy.
2. Choose problems that the children can actively investigate.
3. Offer activities that enable the children to solve problems in a meaningful context.

Kimbell (1986) gives emphasis to role of the teacher for design, problem solving, or both in technology education as an adviser and critic in technological problem solving instruction. He states:

The teacher is essentially an adviser and critic for the child until such time as the child can fully assume the role of self-critic. As this point is reached, the teacher may reduce the frequency and extent of his own criticisms. However this state of personal autonomy is only achieved with maturity and understanding and the foundations of such understanding are laid by the teacher in these critical foundation years. (p. 159)
The teacher's role as a questioning adult is supported by Waetjen. He suggests four kinds of questions and specific explanations of each that teachers can use in order to help students in solving problems in technology education. Waetjen also relates them to his problem solving process consisting of six steps and recommends them to use the appropriate steps as follows:

Memory and recall questions- These call for the lowest level of intellectual functioning and should be used sparingly. For example is: 'What is steel?' To answer, the student goes to his memory bank and gives the correct answer.

Grouping or categorizing questions- Questions of this type require students to group or categorize information that previously was held separately in memory. For example: 'Which of the following are similar or dissimilar and why? Cold rolled steel, brass, tin, hot rolled steel, stainless steel, bronze and copper.' Here the learner must go to memory, determine characteristics of various metals, contrast them, and ultimately develop categories according to hardness . . . or, corroding . . . or color. A teacher is well served to ask questions of this type when students are at Steps 'define the problem' and 'reform the problem' [sic], of the problem solving process.

Transformation questions- To respond to such a question students must change or transform information from one form to another. That is, 'Describe a U.S. Standard thread in geometric terms.' The student would draw on memory of screw threads and geometry, recognize that a U.S. standard thread is actually an isosceles triangle and then describe how one becomes the other. The conceptual data is the same but the form of representation is not only different but at a higher level of intellectual functioning. Transformation questions would be helpful for the teacher to use at Step 'restructure plan' [sic] of the problem solving process when students have failed in their first solution and are devising another plan. By posing a transformation type question, the teacher encourages the learner to develop heuristics, to seek alternative that grow out of similarities.

Cognitive leap questions- These questions require one to provide an entirely hypothetical response to a question for which there is a no 'correct' answer. An example would be: 'How would you design and make a settling tank that
separates waste chemicals before the automatically operated gate valve operates?" Obviously, the dimension added to this question requires considerable extension of cognition into chemistry and related fields. This type of question is particularly appropriate at Step 'synthesis solution' of the problem solving process when one is identifying the cognitive strategies used to solve the problem, and their applicability to other problems. In this instance the teacher modified the original problem somewhat and caused the student to examine the heuristics used and how they might apply in a related situation. (p. 11)

Assessment Method

The measurement of student achievement can take a variety of forms in the classroom such as formal or informal, individual or group, and standardized or tailored to the specific context. Stiggins, Rubel, and Quellmalz (1988) suggest three of the most common forms of assessment methods: oral questions during the instruction, paper-and-pencil tests, and performance tests. They explain characteristics each of them as follows:

Oral questions: The questions teachers ask during instruction to (1) stimulate thought and discussion among students and (2) gather a brief sample of evidence by which to monitor student’s skill development and achievement. Oral questions can stimulate students to think creatively, stretching and exploring interpretations of the knowledge at their disposal. They can be directed to an individual student or asked of the class as a whole to stimulate a discussion. They are open-ended, often allowing for more than one correct answer. ..

Paper-and-pencil tests . . . include the test items teachers prepare for their more formal written tests and quizzes that are used for diagnosis, grading, or placement. Such test questions have traditionally been used to measure students ability to think convergently to arrive at a best or correct answer; however, open-ended formats are also used . . . Paper-and-pencil tests can be used for in-progress monitoring or for more formal assessment conducted after instruction is completed . . .
Performance tests: The teacher observes and judges an activity in progress or a product developed by the student. Students are presented with a set of instructions (the performance exercise), they respond in some overtly behavioral manner, and the teacher observes and evaluates the quality of the behavior and/or the resulting product in terms of prespecified performance standards or criteria. Performance tests might be formal assessment used for grading purpose or less formal assessment integrated into instruction. . . . Performance assessments call upon students to demonstrate what they know by doing it and, in some instance, to explain their strategies. (p. 9-10)

Summative, formative, and diagnostic evaluation are recommended in the technological problem solving instruction not only for evaluation of a student's work but also for the teacher and student who wish to improve their teaching, performance or achievement (Bagshaw et al., 1991; Kimbell, 1986).

Kimbell (1986) gives emphasis to the importance of criteria selection for an assessment of students' work. He suggests four criteria that must be considered based on analyzing design or problem solving process: (a) the quality of idea development, (b) the quality of the solution, (c) the quality of the end product, and (d) the quality of subsequent evaluation by the student.

Breckon, Finney and Fowler (1986b) point two factors that should be considered in assessing students' work: (a) "the level of performance will be related to the difficulty of the task set" and (b) "to the amount of assistance given by the teacher" (p. 14). They also suggest a range of criteria for the performance
of the pupils including (a) design skills, (b) communication skills, (c) realization skills, (d) evaluation skills, (e) attitudes, and (f) homework.

Summary

A review of literature on technology education around the world shows that problem solving as an integral part of technology education is spreading world wide more than ever. There has been a growing interest in problem solving as a curriculum organizer or teaching-learning method in the international technology education field.

The following was discussed in this chapter: (a) the current status of international technology education and problem solving in technology education including the United Kingdom and the United States, (b) the nature of problem solving including definition and process, and (c) the implementation of problem solving in education with respect to curriculum, the instructional strategy, role of teacher, and assessment method.

Problem solving often has been confused with design in the field of technology education. In other words, design often was used roughly equally to problem solving in the field. In short, the essence of problem solving is the application of knowledge and process that leads to a solution of a problem.
Much research has been done about the process of problem solving than any other facts. While British technology educators have been interested in design process, technology educators in the United States have focused on the process of problem solving. Something common in various analyses and models of the processes is that they are complicated and perceived as not a linear process. Most of the design and problem solving processes have the common components such as (a) good problem solving statements, (b) research and development, (c) testing of solutions, (d) evaluation.

Curricula, including goals and objectives, and content of problem solving in the field of education are diverse. Problem solving has been perceived as a good way to foster thinking skills both in the United Kingdom and the United States. In general, manufacturing has used problem solving as content more than construction, energy and power, and communication in the field of technology education.

Concerning the implementation of problem solving, (a) lecture, demonstration, and reading for related content and prerequisites, (b) seminar, panel discussion, contract, and discovery for learning and gathering relevant information were preferred for problem solving instruction in the field of technology education. Many research results show group problem
solving activity is more effective than individual problem solving activity in terms of the number of problems solved and speed of solution. Generally, teacher as a facilitator was understood as an appropriate role of the teacher in problem solving instruction among various roles.
CHAPTER 3

METHODOLOGY

'Knowledge,' in the sense of information, means the working capital, the indispensable resources of further inquiry, of finding out or learning, more things. Frequently, it is treated as an end in itself, and then the goal becomes to heap it up and display it when called for. This static, cold-storage ideal of knowledge is inimical to educative development. It not only lets occasions for thinking go unused, but it swamps thinking. (John Dewey, 1966, p. 158)

The design of this study was descriptive research. United States and British problem solving in technology education at the secondary level with regard to its definition, curriculum, implementation, and proportion was investigated and compared. To achieve an understanding of problem solving in technology education at the secondary level in the United Kingdom and the United States, descriptive data were collected through a mail survey. The mail survey was considered appropriate for obtaining descriptive data for this study since the research involves assessing attitudes and opinions toward problem solving in technology education in the United Kingdom and the United States. The mail survey is also considered appropriate for obtaining descriptive data for the study since participants
selected for the study are widely spread geographically in the United Kingdom and the United States.

This chapter is organized into four sections reflecting the methodological activities used to accomplish the objectives of the study. The sections include: (a) population and sample, (b) instrumentation, (c) data collection, and (d) data analysis.

**Population and Sample**

The target population of the study consisted of administrators and university professors in the field of technology education in the United Kingdom and the United States. Key experts of problem solving in technology education at the secondary level in these two countries were chosen for the sample. Twenty-nine subjects, composed of 15 subjects in the United Kingdom and 14 in the United States, were selected as key experts in the countries.

A purposive sampling procedure was employed to select professionals of technological problem solving in secondary education. The key experts had to meet at least two of the criteria established for selection: (a) presented papers on problem solving in technology education at domestic or international conferences on education; (b) published article(s) about problem solving in technology education in journals of education; (c) wrote book(s) on technology education, including
problem solving for technology educators, students, or both; and (d) considered to have a deep interest in the problem and important knowledge or experience to share about problem solving in technology education at the secondary level.

The following five steps were taken to select experts for the pilot study and the survey in the study. First, through a literature review, United States and British technology educators were identified who met at least one or more of the established criteria. Sixty-three experts, 30 in the United Kingdom and 33 in the United States, were identified in this step. Second, for the participants in the survey, 33 key experts were identified who met two or more of the established criteria for the years 1986 through 1996 among the 63 specialists identified in the first step. Third, 30 technology educators were chosen who met one of the established criteria for the years 1986 through 1996 as the subjects for the pilot study. These 30 experts were the remainder of the 63 professionals identified in the first step exclusive of the 33 key experts chosen for the survey. A tentative list of participants for the pilot study and actual study was made on the basis of technology educators identified in the previous steps as experts on problem solving in technology education at the secondary level. Fourth, the researcher consulted an expert on problem solving in technology education, who was familiar with technology education in both the United Kingdom and the United States about the following study participants: (a) for the participants in the
survey, to recommend key experts who deserve to be participants for the survey although they were not on the tentative list of the participants for the survey but on the tentative list of the participants for the pilot study; (b) to select experts who deserve to be participants for the pilot test and field test on the tentative list of the participants for the pilot study; and (c) for the participants in the pilot study, to recommend experts of problem solving in technology education who were considered to be able to contribute to the field test and pilot test although they were not in the tentative list of the participants for the pilot study. Fifth, using the established criteria and consulting with the specialist of technology education including problem solving, who was familiar with technology education in the two nations, final participants were decided for the survey and the pilot and field tests. Finally, 29 key experts on problem solving in technology education at the secondary level, 14 in the United States and 15 the United Kingdom, were selected for the participants in the survey exclusive of the four key experts who have retired, had unknown address, or both. The field test group consisted of four professionals of technological problem solving in secondary education composed of two technology educators each in the United Kingdom and the United States. (See Appendix A) The pilot test group consisted of 26 technology educators as experts on problem solving in technology education at the secondary level, 15 United States and 11 British technology educators. Both the
STEP 1

Identifying technology educators who met one or more of the four established criteria

63 technology educators as experts
UK: 29, US: 31

STEP 2

Met two or more of the established criteria

33 key experts
UK: 17, US: 16

STEP 3

Met one or more of the established criteria

30 experts
UK: 13, US: 17

STEP 4: Consulting with the specialist

Discarded
4 experts

STEP 5: Final selection

29 key experts for the actual study
UK: 15, US: 14

4 experts for field test
UK: 2, US: 2

26 experts for pilot test
UK: 11, US: 15

Figure 5. Selection process of the study participants
field and pilot test participants were excluded from the actual study. These processes were conducted with the assistance of Dr. Karen F. Zuga, Design and Technology Special Interest Group co-chair (1995) of the American Educational Research Association, Board of Directors (1991-94) of International Technology Education Association, Board of Directors (1993-1995) of the National Association for Science, Technology and Society, and President (1987-1990) of Technology Education for Children Council.

Instrumentation

A specialized instrument based upon a review of literature was developed to clarify the concepts being studied. Through the review of the literature an extensive list of possible questionnaire items was compiled. These items were then reviewed, analyzed, and selected for the initial draft of the instrument based on their appropriateness for answering the research questions posed in the study.

The questionnaire was divided into four sections. The first section consisted of items seeking information related to the goals and curriculum content of problem solving in technology education at the secondary level. The second section of the questionnaire consisted of items about the implementation of problem solving in technology education including instructional
strategies, the teacher's role, assessment methods, and the proportion of time spent on problem solving. The third section sought information related to how to define problem solving in technology education. The final section included an item that requested general comments concerning any additional aspects of problem solving in technology education for secondary students.

Establishing Validity

Content validation is considered to be the single most important method for improving the usefulness of an instrument lacking validity and reliability. In order to establish content validity, the following approaches were applied in the study. The instrument was reviewed and assessed by a small group of experts who consisted of committee members for the dissertation research. Review and assessment were performed both during and after the development of the instrument. Advice and comments were reflected in the content of the instruments.

For establishing face validity, a field test was performed to examine items on the instrument in relation to wording, content, format, clarity, appropriateness and importance of each question of four sections in the questionnaire with a group of four professionals of problem solving in technology education composed of two each in the United Kingdom and the United States. In addition, the revised instrument which reflected feedback from the group of experts and results of the field test
was reviewed again by the group of experts. The comments and opinions of the second review by the group of experts are reflected in the instrument.

Establishing Reliability

Reliability is considered as a benchmark criterion for assessing the consistency of the instrument in measuring accurately whatever it sets out to measure. When the instrument was developed, attention was paid to the following for the purpose of improving reliability: (a) writing clearly, (b) avoiding ambiguous items, (c) adding more items, (d) providing clear and standard directions, (e) providing enough time to complete the instrument, and (f) providing independent and homogeneous items or questions (Draghi, 1991).

To assess the reliability of the survey instrument, the test-retest method was employed because alternate or equivalent forms of a test were not available and items of the instrument were not summated but ranked. The test-retest was administered to the pilot test participants using the procedures planned for the actual study. Respondents of the pilot test consisted of nine American technology educators and six British experts on problem solving in technology education at the secondary level. (See Appendix B) One week later, after receiving responses to the first instruments, the second set of instruments was administered again to the same participants in the same manner.
The high agreement rate between the results of the two administrations of the test shows that the instrument is reliable and gives consistent results. Gay explains reliability coefficients as follows:

What constitutes an acceptable level of reliability is to some degree determined by the type of test although, of course, a coefficient over .90 would be acceptable for any test. The question really is concerned with what constitutes a minimum level of acceptability. For achievement and aptitude tests, there is generally no good reason for selecting a test whose reliability is not at least .90. There are number of achievement and aptitude tests available that report such reliabilities and it is therefore not usually necessary to settle for less. Personality measures do not typically report such high reliabilities (although certainly some do) and one would therefore be very satisfied with a reliability in the eighties and might even accept a reliability in the seventies. When tests are developed in new areas, one usually has to settle for lower reliability, at least initially. For example, tests which measure curiosity are a relatively recent addition to the testing field. One would not expect high reliabilities for these new tests at this stage of their development (p. 168).

The average percentage of agreement between the responses on the first administration and second administration of the instrument was 73.9% which shows that the specialized survey instrument newly developed for the study is reliable.

The high percentage of agreement could be affected by the short length of time—around 10 days—that elapsed between the two administrations of the test. The longer the time interval, the lower the agreement rate is likely to be, because there is a probability of changes in the individuals taking the test.
However, in this study, the perceptions of key experts on problem solving in technology education were considered to be more stable than any others since the experts were considered to have a their own opinion and expertise based on their research and experience. Therefore, there was a low likelihood of changes in the individuals taking the test. The range of percents of agreement by question is shown in Table 2.

<table>
<thead>
<tr>
<th>Questions of Instrument</th>
<th>Percent of Agreement (n = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1 Goals</td>
<td>76.9</td>
</tr>
<tr>
<td>No. 2 Curriculum Content</td>
<td>73.9</td>
</tr>
<tr>
<td>No. 3 Instructional Strategies</td>
<td>74.3</td>
</tr>
<tr>
<td>No. 4 Teacher’s Role</td>
<td>73.5</td>
</tr>
<tr>
<td>No. 5 Assessment Methods</td>
<td>70.7</td>
</tr>
<tr>
<td>Grand Mean</td>
<td>73.9</td>
</tr>
</tbody>
</table>

Table 2. Percentage of agreement of test-retest

Question No. 6 and 7 were excluded in calculating the percentage of agreement. These two questions, which sought information related to the proportion of problem solving in technology education and how to define problem solving in technology
education, are not applicable to calculation of the percentage of agreement because they are open-end questions. The researcher created categories and grouped the definitions using the categories somewhat like a simplified Q-sort technique. In order to strengthen the reliability of the grouping, another technology professional sorted the definitions into categories that had been established. The percentage of agreement between the professional and researcher was 90.5%. (See Appendix K) A coefficient over .90 is an acceptable level of reliability for any test (Fraenkel & Wallen, 1996; Gay 1992).

Data Collection

A mail survey was appropriate for the study as the purpose was to gather information from the participants. The questionnaires were mailed using two methods: postal mail or e-mail.

The survey instruments were sent by surface mail to United States participants or by air mail to British participants who did not use e-mail. For the sake of receiving as many usable questionnaires as possible, the following strategies were employed according to Dillman's (1978) and Fowler's (1988) suggestions for postal mailing. Mail the first packet with the first postal packet including (a) a cover letter on university letterhead which was co-signed by the researcher and his advisor, (b) an attractively designed questionnaire, using quality yellow paper with questions spaced in an uncluttered
manner to make them easy to read, containing a colorful graphic illustration on the front page, and in booklet form, (c) a pre-addressed and stamped return envelope, and (d) an incentive was provided—token gifts of a pen and tea bag and sending respondents a summary of the study results. Second, a follow-up was conducted one week after the first mailing. A postcard was sent to both respondents and non-respondents. The purpose of sending the postcard was twofold: to thank the people who responded and to remind kindly and courteously people who had not. Third, a second follow-up was conducted three weeks after the first postal mailing. A letter and replacement survey were sent only to non-respondents. This second mailing had a shorter cover letter that informed non-respondents that their survey had not been received and appealed for its return. Finally, a fax was sent to non-respondents to appeal for the return of the completed questionnaire five weeks after the first postal mailing.

For the respondents who used e-mail, the instruments were delivered via the Internet. The first e-mail packet consisted of the cover letter and the questionnaire. At the same time, another separate postal mail packet including a cover letter on university letterhead which was co-signed by the researcher and advisor, and tokens of appreciation were sent by surface mail for respondents in the United States and air mail for respondents in the United Kingdom. The purpose of sending the separate postal mail was threefold: (a) to send the tokens, (b)
to provide a hard copy of the questionnaire for the e-mail user who preferred a hard copy of the questionnaire to the e-mail version of the questionnaire or who did not know how to reply and return the questionnaire by e-mail, and (c) to remind the respondents kindly and courteously that they had messages that requested their help in a survey for the dissertation study.

A follow-up was conducted one week after the first electronic mailing. An electronic message was sent by e-mail to non-respondents. The purpose of sending the message was to remind kindly and courteously people who had not responded to the survey. The second follow-up was conducted two weeks after the first electronic mailing. The e-mail version of a letter and replacement survey was sent by e-mail to non-respondents. This second mailing had a shorter cover letter that informed non-respondents that their survey had not been received and appealed for its return. Finally, a fax was sent to non-respondents to remind and appeal to return the completed questionnaire.

The rate of response was 93.1%. Twenty-seven out of 29 technology educators as key experts responded to the survey. (See Appendix C for participants in the survey) Fourteen responses out of 14 respondents in the United States and 13 responses out of 15 respondents in the United Kingdom arrived by the end of August 1996.
Data Analysis

Descriptive statistics were used to describe, synthesize, analyze, and interpret the data that had been collected from the participants in this study. The computer program, Statistical Program for the Social Sciences (SPSS for MS WINDOWS Release 6.1), was used for data analysis of questions 1 through 6 in the questionnaire. Responses to each item were analyzed by following steps:

1. Each item in the first and second sections was treated as interval data and a mean score with an accompanying standard deviation was calculated. The mean score was calculated on a four-point Likert scale with 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

2. The items in the first and second sections were rank ordered by mean scores and standard deviation.

3. A Spearman rank-order correlation (rho) was calculated from two sets of rank ordered perceptions of United Kingdom and United States key experts on Question one through five in the questionnaire. A higher Spearman correlation coefficient indicated a higher level of agreement between the two groups.

4. For responses to third section, the definitions of problem solving in technology education were analyzed by content analysis. For the content analysis of the definitions of problem solving in technology education, words and themes were used as units of analysis. Trends, pattern,
similarities, and differences of the definitions in the United Kingdom and the United States were described.

Summary

This chapter presented the methodology for the study. The design of this study was descriptive research. To achieve understanding of problem solving in secondary technology education in the United Kingdom and the United States, a mail survey was used. The questionnaires were mailed and collected using two methods: postal mail and e-mail. The target population of the study consisted of administrators and university professors in the field of technology education in the two nations. Participants in the study were drawn from key experts of problem solving in technology education in the United Kingdom and the United States. A purposive sampling procedure was employed to select the key experts of technological problem solving in secondary education.

A specialized instrument was developed based upon a review of literature in order to clarify the concepts being studied. In order to establish validity of the instrument, field testing, reviewing, and assessing of panel experts during and after the development of the instrument were performed in this study. To assess reliability of the instrument, the test-retest method was employed. The test-retest was administered to the pilot test participants using the procedures planned for the actual study.
The questionnaires were mailed and returned using two main methods: postal mail or e-mail. Responses to the questions were analyzed by following steps:

1. The items in the first and second sections were rank ordered by mean scores and standard deviation, and a Spearman rank-order correlation (rho) coefficient was calculated.

2. Responses to the third section for problem solving definition were analyzed by content analysis.
CHAPTER 4

FINDINGS

The rapid changes in technological development have made it impossible to teach content by merely providing facts. Knowledge has doubled in the past decade, and will probably treble in the next. We are, therefore, confronted with the responsibility of developing the curriculum to meet the need of the 21st century and at the same time change the way we educate in order to develop the full range of learning skills. (Peter Sellwood, 1989, p. 3)

The data were collected in the process of investigating the research questions through the survey and meeting the objectives stated in Chapter 1, and in accordance with the research methods described in Chapter 3. The findings of the study are organized into five headings according to the research questions presented in Chapter 1:

1. definition of problem solving in technology education,
2. curriculum of problem solving including goals and content,
3. implementation of problem solving such as instructional strategies and role of teacher,
4. assessment methods of problem solving competence, and
5. proportion of problem solving in technology education at the secondary level in the United Kingdom and the United States.
Definition of Problem Solving in Technology Education

A variety of definitions of problem solving in technology education were reported by the United Kingdom and the United States technology educators. Most frequently used concepts were 'design' and 'process' to define and explain problem solving in technology education by the eight United Kingdom and 13 United States experts. Among 21 definitions of problem solving in the two countries, the terms 'design' was used 22 times, five times in British definitions and 17 times in American definitions, to define and explain problem solving in technology education. The term 'process' was used 13 times, five times in British definitions and eight times in American definitions to define problem solving in technology education.

Twenty-one definitions of problem solving in technology education were categorized into the following categories.

1. Practical success in doing and making an artifact such as "the problem solving is principally of practical nature . . . In endeavoring to satisfy, through technology, human needs and wants, and identified market opportunities, technology activities involves the solving of practical problems which employ particular intellectual and physical resources in their resolution".

2. Process of resolving difficulties or dilemmas like the following definition: "an adoptive and flexible ongoing process of resolving genuine dilemmas".
3. Design or use of the design process including the following definition: “Design and problem solving is the translation of ideas into a tangible product, system or environment. It provides a plan that includes how to make, test and improve the proposed and implemented design”.

4. Use or application of thought process or intellectual activity or resources such as “the application of a systematic thought process to seek and apply solutions to technological needs”.

5. Application or use of knowledge, skills, and experience as shown in the following definition: “the creative use of knowledge, skills and experience to produce technique, tools and items that people need”.

6. Others including the following definition: “I don’t think there is one universal definition. I would categorize technological problem solving into several areas including design and problem solving, production type problem solving (problems that occur while new designs are being tested and produced), and service problem solving (maintenance and repair type problems). The contextual differences between these three problem types are important and seem to influence the problem solving processes that are used”.

Table 3 shows cases of each categories by country.
### Table 3. Definition of Problem Solving in Technology Education

<table>
<thead>
<tr>
<th>Category</th>
<th>UK (N=8)</th>
<th>US (N=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practical success in doing and making an artifact</td>
<td>1 13 %</td>
<td>0 0 %</td>
</tr>
<tr>
<td>Process of resolving difficulties or dilemmas</td>
<td>3 38 %</td>
<td>4 31 %</td>
</tr>
<tr>
<td>Design or use of design process</td>
<td>1 13 %</td>
<td>3 23 %</td>
</tr>
<tr>
<td>Use or application of thought process or intellectual activity or resources</td>
<td>0 0 %</td>
<td>2 15 %</td>
</tr>
<tr>
<td>Application or use of knowledge, skills, and experience</td>
<td>2 25 %</td>
<td>3 23 %</td>
</tr>
<tr>
<td>Others</td>
<td>1 13 %</td>
<td>1 8 %</td>
</tr>
</tbody>
</table>

Curriculum of Problem Solving in Technology Education

In this section, the curriculum of problem solving in technology education is discussed. It is divided into two sections pertaining to goals and content.
Goals of Problem Solving in Technology Education

Among the variety of possible goals of problem solving in technology education, United States technology educators agreed most with the following as goals of problem solving in technology education at the secondary level, in rank order:
1. develop thinking skills such as creative thinking, critical thinking, decision making and others;
2. develop planning and making skills;
3. understand and use materials, tools and mechanisms;
3. develop research and investigation skills;
5. develop designing skills;
6. apply experience in technology education to practical problem or other subjects; and
7. apply experience in other subjects to technology education.

United States technology educators disagreed most with the following as goals of problem solving in technology education, in rank order:
1. develop an interest in safety with respect to materials, techniques, and processes;
2. become critical of products used in everyday life;
3. create a deeper interest and commitment to improving the quality of life;
4. understand and apply control or technical systems; and
5. explore and experience technology.
On the other hand, British technology educators agreed with goals of problem solving in technology education as follows, in rank order:

1. develop designing skills,
2. develop research and investigation skills,
3. develop planning and making,
4. develop thinking skills,
5. explore and experience technology, and
6. understand and apply technological systems.

In rank order, five goals that British experts on problem solving in technology education disagreed with most were as follows:

1. apply experience in technology education to practical problem or other subjects;
2. develop an interest in safety with respect to materials, techniques, and processes;
3. become critical of products used in everyday life;
4. create a deeper interest and commitment to improving the quality of life for oneself and others;
5. analyze the interaction of technology on individuals, society, and environment; and
6. evaluate existing designs or products.

Table 4 shows the ranking of the 16 goals for problem solving in technology education at the secondary level by each country.
<table>
<thead>
<tr>
<th>Goals of Problem Solving</th>
<th>Mean (UK)</th>
<th>SD</th>
<th>Rank Order</th>
<th>Mean (US)</th>
<th>SD</th>
<th>Rank Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explore &amp; experience technology</td>
<td>3.38</td>
<td>.65</td>
<td>5</td>
<td>3.21</td>
<td>.89</td>
<td>12</td>
</tr>
<tr>
<td>Develop research &amp; investigation skills</td>
<td>3.54</td>
<td>.52</td>
<td>1</td>
<td>3.57</td>
<td>.65</td>
<td>3</td>
</tr>
<tr>
<td>Develop designing skills</td>
<td>3.54</td>
<td>.52</td>
<td>1</td>
<td>3.46</td>
<td>.52</td>
<td>5</td>
</tr>
<tr>
<td>Develop planning &amp; making skills</td>
<td>3.46</td>
<td>.66</td>
<td>3</td>
<td>3.62</td>
<td>.51</td>
<td>2</td>
</tr>
<tr>
<td>Develop thinking skills</td>
<td>3.46</td>
<td>.88</td>
<td>4</td>
<td>3.77</td>
<td>.44</td>
<td>1</td>
</tr>
<tr>
<td>Develop ability to work independently or in teams</td>
<td>3.31</td>
<td>.48</td>
<td>7</td>
<td>3.29</td>
<td>.73</td>
<td>8</td>
</tr>
<tr>
<td>Evaluate existing designs/products</td>
<td>3.08</td>
<td>.76</td>
<td>11</td>
<td>3.23</td>
<td>.83</td>
<td>11</td>
</tr>
<tr>
<td>Develop an interest in safety</td>
<td>2.67</td>
<td>.65</td>
<td>15</td>
<td>2.93</td>
<td>1.07</td>
<td>16</td>
</tr>
<tr>
<td>Understand &amp; use materials, tools &amp; mechanisms</td>
<td>3.17</td>
<td>.58</td>
<td>10</td>
<td>3.57</td>
<td>.65</td>
<td>3</td>
</tr>
<tr>
<td>Understand &amp; apply technological systems</td>
<td>3.33</td>
<td>.78</td>
<td>6</td>
<td>3.29</td>
<td>.91</td>
<td>10</td>
</tr>
<tr>
<td>Understand &amp; apply control/technical systems</td>
<td>3.18</td>
<td>.75</td>
<td>9</td>
<td>3.07</td>
<td>.92</td>
<td>13</td>
</tr>
<tr>
<td>Apply experience in other subjects to technology education</td>
<td>3.23</td>
<td>.73</td>
<td>8</td>
<td>3.36</td>
<td>.93</td>
<td>7</td>
</tr>
<tr>
<td>Apply experience in technology education to practical problem or other subjects</td>
<td>2.67</td>
<td>.89</td>
<td>16</td>
<td>3.38</td>
<td>.87</td>
<td>6</td>
</tr>
<tr>
<td>Analyze the interaction of technology on individuals, society, &amp; environment</td>
<td>3.00</td>
<td>.58</td>
<td>12</td>
<td>3.29</td>
<td>.83</td>
<td>9</td>
</tr>
<tr>
<td>Create a deeper interest &amp; commitment to improving the quality of life</td>
<td>2.92</td>
<td>.67</td>
<td>13</td>
<td>3.07</td>
<td>1.07</td>
<td>14</td>
</tr>
<tr>
<td>Become critical of products used in everyday life</td>
<td>2.92</td>
<td>.76</td>
<td>14</td>
<td>3.00</td>
<td>.96</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 4. Goals of Problem Solving in Technology Education. Scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree.
Respondents were asked to include other possible goals of problem solving in technology education. Eight of the 27 respondents to Question one suggested the following goals of problem solving in technology education at the secondary level:
a. to learn a procedure for solving problems or address opportunities that can be transferred to real life situations;
b. understand how personal daily lives can influence the lives of others now and in the future;
c. develop self-confidence and self-esteem;
d. encourage 'perseverance' in the testing and improvement of a product;
e. establish new attitudes as well as new ways of thinking and working;
f. learn how to solve problems;
g. aware of economic, environmental issues; and
h. to give pupils experience of a style of thinking rarely found in other subjects. Pupils design what they make and make what they have designed and have to live with the consequences.

Curriculum Content of Problem Solving in Technology Education

Within the diversified curriculum contents of problem solving suggested in the Question two, the United States and the United Kingdom key experts on problem solving in technology education perceived (a) problem solving processes such as defining a problem, setting goals, developing alternatives, selecting the best solution, implementing the solution, and evaluating the
results; and (b) design processes including brief, investigation, ideas, developing idea(s), working drawing or model, making, and evaluation as the best and the second best pertinent curriculum contents of technological problem solving in secondary education respectively. In addition, 'control or technical systems such as structural, mechanical, electrical/electronic, and pneumatic systems' were perceived as the third best pertinent curriculum content of problem solving in technology education for secondary students by technology educators in both the United Kingdom and the United States.

On the contrary, 'specific occupational skills of a vocational nature' and 'specific handicraft' were regarded as the poorest and second poorest pertinent curriculum content by the United States as well as the United Kingdom experts. 'Material process such as separating, combining, and forming' and 'technological systems such as communication, construction, manufacturing, transportation, and others' were perceived as the third poorest pertinent curriculum content of problem solving in technology education among the experts in the United Kingdom and the United States respectively.

The rank order, for each country by mean, of 13 curriculum content of problem solving in technology education at the secondary level are shown in Table 5.
<table>
<thead>
<tr>
<th>Curriculum Content of Problem solving</th>
<th>Mean</th>
<th>U K SD</th>
<th>Rank Order</th>
<th>Mean</th>
<th>U S SD</th>
<th>Rank Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational skills</td>
<td>2.25</td>
<td>.87</td>
<td>13</td>
<td>1.71</td>
<td>.73</td>
<td>13</td>
</tr>
<tr>
<td>Specific handicraft</td>
<td>2.25</td>
<td>.75</td>
<td>12</td>
<td>2.08</td>
<td>.67</td>
<td>12</td>
</tr>
<tr>
<td>Technological systems</td>
<td>3.08</td>
<td>.49</td>
<td>6</td>
<td>3.15</td>
<td>.90</td>
<td>11</td>
</tr>
<tr>
<td>Control systems</td>
<td>3.31</td>
<td>.48</td>
<td>3</td>
<td>3.57</td>
<td>.51</td>
<td>3</td>
</tr>
<tr>
<td>Daily life</td>
<td>3.08</td>
<td>.64</td>
<td>7</td>
<td>3.17</td>
<td>.58</td>
<td>10</td>
</tr>
<tr>
<td>Material processes</td>
<td>2.85</td>
<td>.38</td>
<td>11</td>
<td>3.43</td>
<td>.51</td>
<td>5</td>
</tr>
<tr>
<td>Sources, properties and uses of materials</td>
<td>3.23</td>
<td>.60</td>
<td>5</td>
<td>3.36</td>
<td>.50</td>
<td>6</td>
</tr>
<tr>
<td>Safety</td>
<td>2.92</td>
<td>.49</td>
<td>10</td>
<td>3.36</td>
<td>.50</td>
<td>6</td>
</tr>
<tr>
<td>Problem solving processes</td>
<td>3.69</td>
<td>.63</td>
<td>1</td>
<td>3.85</td>
<td>.38</td>
<td>1</td>
</tr>
<tr>
<td>Design processes</td>
<td>3.50</td>
<td>.52</td>
<td>2</td>
<td>3.69</td>
<td>.48</td>
<td>2</td>
</tr>
<tr>
<td>Social concerns</td>
<td>3.00</td>
<td>.71</td>
<td>9</td>
<td>3.25</td>
<td>.87</td>
<td>9</td>
</tr>
<tr>
<td>Students' interests</td>
<td>3.08</td>
<td>.86</td>
<td>8</td>
<td>3.31</td>
<td>1.03</td>
<td>8</td>
</tr>
<tr>
<td>Influence of technology</td>
<td>3.25</td>
<td>.62</td>
<td>4</td>
<td>3.54</td>
<td>.52</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 5. Curriculum Content of Problem Solving in Technology Education. Scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree

Six out of 27 technology educators in the two nations recommended additional areas for curriculum content of problem solving in technology education for secondary students:
a. thinking skills such as categorizing, prioritizing, and transforming;
b. knowledge processing skills such as sketching and writing;
c. application and use of knowledge and information processing tools (computer and calculators);
d. future issues as well as global perspectives;
e. tool skills related to materials, energy and information;
f. to foster a 'self critical' approach in the evaluation of a product;
g. to foster an eye for simplicity and elegance in any solution as well as economic utility;
h. demands intellectual effort; and
i. authentic situations.

Implementation of Problem Solving in Technology Education

Information regarding the implementation of problem solving in technology education is provided in this section. Instructional strategies and teachers' role in the classroom are discussed.

Instructional Strategy of Problem Solving

Among various instructional strategies for problem solving in technology education asked of respondents, British key experts on problem solving in technology education recognized the following as the most appropriate instructional strategies for
technological problem solving in secondary education, in rank order:

1. project or activity methods,
2. discussion,
3. brainstorming,
4. student team,
5. field observation or field trips,
6. tutoring,
7. simulations,
8. discovery learning,
9. role play, and
10. individualized instruction.

United States experts on problem solving in technology education recognized the following as the most appropriate instructional strategies, in rank order:

1. brainstorming,
2. project or activity methods,
3. simulation,
4. student team,
5. discussion,
6. case study,
7. individualized instruction,
8. oral report,
8. competition, and
10. discovery learning.
On the other hand, (a) recitation, (b) lecture, and (c) protocol were perceived as the least, second, and third least appropriate instructional strategies by United States and British key experts on problem solving in technology education.

Table 6 shows the rankings of the 21 instructional strategies for problem solving in technology education at the secondary level by the United Kingdom and the United States. In addition to the listed instructional strategies, five of the 24 respondents suggested:

a. critics of existing products or acts,
b. 'continuous' response to a set of structured motivating tasks ('a programme'),
c. problem(s) based learning,
d. constrained to open-ended design activity,
e. critique,
f. guided participation in problem solving, and
g. scaffolding learning.
<table>
<thead>
<tr>
<th>Instructional Strategy of Problem Solving</th>
<th>Mean</th>
<th>U K SD</th>
<th>Rank Order</th>
<th>Mean</th>
<th>U S SD</th>
<th>Rank Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic game</td>
<td>2.67</td>
<td>.71</td>
<td>15</td>
<td>2.75</td>
<td>.87</td>
<td>15</td>
</tr>
<tr>
<td>Brainstorming</td>
<td>3.50</td>
<td>.52</td>
<td>3</td>
<td>3.54</td>
<td>.52</td>
<td>1</td>
</tr>
<tr>
<td>Case study</td>
<td>2.90</td>
<td>.57</td>
<td>11</td>
<td>3.15</td>
<td>.55</td>
<td>6</td>
</tr>
<tr>
<td>Center of interest and display</td>
<td>2.78</td>
<td>.44</td>
<td>12</td>
<td>2.64</td>
<td>.81</td>
<td>18</td>
</tr>
<tr>
<td>Colloquia</td>
<td>2.44</td>
<td>.53</td>
<td>17</td>
<td>2.67</td>
<td>.65</td>
<td>17</td>
</tr>
<tr>
<td>Competition</td>
<td>2.67</td>
<td>.87</td>
<td>16</td>
<td>3.00</td>
<td>.82</td>
<td>8</td>
</tr>
<tr>
<td>Contracts</td>
<td>2.44</td>
<td>.53</td>
<td>17</td>
<td>2.83</td>
<td>.72</td>
<td>12</td>
</tr>
<tr>
<td>Demonstration</td>
<td>2.73</td>
<td>.65</td>
<td>13</td>
<td>2.69</td>
<td>.63</td>
<td>16</td>
</tr>
<tr>
<td>Discovery learning</td>
<td>3.09</td>
<td>.70</td>
<td>8</td>
<td>3.00</td>
<td>.91</td>
<td>10</td>
</tr>
<tr>
<td>Discussion</td>
<td>3.58</td>
<td>.51</td>
<td>2</td>
<td>3.23</td>
<td>.83</td>
<td>5</td>
</tr>
<tr>
<td>Field observation/ field trips</td>
<td>3.33</td>
<td>.49</td>
<td>5</td>
<td>2.77</td>
<td>.73</td>
<td>13</td>
</tr>
<tr>
<td>Individualized instruction</td>
<td>3.00</td>
<td>.94</td>
<td>10</td>
<td>3.00</td>
<td>.71</td>
<td>7</td>
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<tr>
<td>Lecture</td>
<td>2.00</td>
<td>.77</td>
<td>20</td>
<td>2.54</td>
<td>.66</td>
<td>20</td>
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<tr>
<td>Oral reports</td>
<td>2.73</td>
<td>.65</td>
<td>13</td>
<td>3.00</td>
<td>.82</td>
<td>8</td>
</tr>
<tr>
<td>Project or activity methods</td>
<td>3.73</td>
<td>.47</td>
<td>1</td>
<td>3.42</td>
<td>.90</td>
<td>2</td>
</tr>
<tr>
<td>Protocols</td>
<td>2.29</td>
<td>.76</td>
<td>19</td>
<td>2.56</td>
<td>.73</td>
<td>19</td>
</tr>
<tr>
<td>Recitation</td>
<td>1.63</td>
<td>.52</td>
<td>21</td>
<td>2.18</td>
<td>.75</td>
<td>21</td>
</tr>
<tr>
<td>Role play</td>
<td>3.08</td>
<td>.67</td>
<td>9</td>
<td>2.92</td>
<td>.76</td>
<td>11</td>
</tr>
<tr>
<td>Simulations</td>
<td>3.17</td>
<td>.39</td>
<td>7</td>
<td>3.31</td>
<td>.63</td>
<td>3</td>
</tr>
<tr>
<td>Student teams</td>
<td>3.42</td>
<td>.67</td>
<td>4</td>
<td>3.31</td>
<td>.85</td>
<td>4</td>
</tr>
<tr>
<td>Tutoring</td>
<td>3.22</td>
<td>.83</td>
<td>6</td>
<td>2.75</td>
<td>.62</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 6. Instructional Strategy of Problem Solving in Technology Education. Scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree
The section on the teacher's role consisted of two parts: statements of the teacher's activity and statements of teacher behavior patterns related to problem solving instruction in technology education program.

British experts on problem solving in technology education recognized the following as the most suitable teacher activities for technological problem solving instruction, in rank order:
1. Involves students in meaningful dialogue,
2. Provides design briefs,
3. Chooses problems for the students,
4. Provides examples and answers,
5. Tightly controls activities, and
6. Does not intervene.

In the United States, teacher activities ranked most suitable for problem solving in technology education for secondary students were:
1. Involves students in meaningful dialogue,
2. Provides examples and answers,
3. Provides design briefs,
4. Chooses problems for the students,
5. Does not intervene, and
6. Tightly controls activities.
Table 7 shows the rank order and mean score of the teacher’s role in problem solving instruction in terms of teacher activity by each country.

<table>
<thead>
<tr>
<th>Activities in Problem Solving in Technology Education</th>
<th>UK (N = 13) Mean</th>
<th>SD</th>
<th>Rank Order</th>
<th>US (N = 13) Mean</th>
<th>SD</th>
<th>Rank Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does not intervene</td>
<td>1.38</td>
<td>.51</td>
<td>6</td>
<td>2.08</td>
<td>.95</td>
<td>5</td>
</tr>
<tr>
<td>Chooses problems for students</td>
<td>2.69</td>
<td>.85</td>
<td>3</td>
<td>2.67</td>
<td>.78</td>
<td>4</td>
</tr>
<tr>
<td>Involves students in meaningful dialogue</td>
<td>3.77</td>
<td>.44</td>
<td>1</td>
<td>3.62</td>
<td>.51</td>
<td>1</td>
</tr>
<tr>
<td>Provides examples and answers</td>
<td>2.45</td>
<td>.82</td>
<td>4</td>
<td>3.00</td>
<td>.60</td>
<td>2</td>
</tr>
<tr>
<td>Tightly controls activities</td>
<td>2.15</td>
<td>.99</td>
<td>5</td>
<td>2.00</td>
<td>.74</td>
<td>6</td>
</tr>
<tr>
<td>Provides design briefs</td>
<td>2.69</td>
<td>.63</td>
<td>2</td>
<td>3.00</td>
<td>.71</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 7. Teacher's Activities in Problem Solving in Technology Education. Scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree

In addition to the six activities, five out of 25 respondents suggested the following as other appropriate teacher activities for problem solving instruction in technology education program:
a. avoids sexism or racism,
b. provides progression in learning,
c. permits pupil autonomy and structures tasks accordingly,
d. provides cognitive tools for making students thinking explicit, and
e. encourages students to identify problems.

The top five roles of the teacher in terms of behavior patterns that British respondents felt most appropriate for problem solving instruction in technology education program were:
1. Serves as a facilitator,
2. Serves as an adviser,
3. Serves as an expert consultant,
4. Serves as a questioning adult, and
5. Serves as a manager of the learning situation.

In the United States, the top five roles of the teacher in terms of behavior patterns that key experts on technological problem solving felt most appropriate in problem solving instruction were:
1. Serves as a facilitator
2. Serves as a source of relevant knowledge
3. Serves as a questioning adult
4. Serves as a manager of the learning situation, and
5. Serves as a evaluator of students' work.

On the other hand, 'to serve as a source of opinions, attitudes and values' was perceived as the least appropriate behavior
pattern in problem solving instruction in technology education program in the United States, while British technology educators perceived 'to serve as an observer' as the least appropriate behavior pattern. Table 8 shows the rank order and mean scores of each teacher's role in terms of behavior patterns by each country.

<table>
<thead>
<tr>
<th>Behavior Pattern in Problem Solving</th>
<th>Mean</th>
<th>UK SD</th>
<th>Rank Order</th>
<th>Mean</th>
<th>US SD</th>
<th>Rank Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitator</td>
<td>3.54</td>
<td>.52</td>
<td>1</td>
<td>3.77</td>
<td>.44</td>
<td>1</td>
</tr>
<tr>
<td>Source of relevant knowledge</td>
<td>3.42</td>
<td>.90</td>
<td>6</td>
<td>3.64</td>
<td>.50</td>
<td>2</td>
</tr>
<tr>
<td>Expert consultant</td>
<td>3.50</td>
<td>1.00</td>
<td>3</td>
<td>3.45</td>
<td>.52</td>
<td>6</td>
</tr>
<tr>
<td>Manager of the learning situation</td>
<td>3.42</td>
<td>.79</td>
<td>4</td>
<td>3.58</td>
<td>.51</td>
<td>3</td>
</tr>
<tr>
<td>Negotiator</td>
<td>3.27</td>
<td>.79</td>
<td>7</td>
<td>3.36</td>
<td>.50</td>
<td>8</td>
</tr>
<tr>
<td>Questioning adult</td>
<td>3.42</td>
<td>.79</td>
<td>4</td>
<td>3.58</td>
<td>.51</td>
<td>3</td>
</tr>
<tr>
<td>Source of opinions, attitudes and values</td>
<td>2.91</td>
<td>.83</td>
<td>10</td>
<td>3.00</td>
<td>.77</td>
<td>11</td>
</tr>
<tr>
<td>Observer</td>
<td>2.82</td>
<td>.75</td>
<td>11</td>
<td>3.18</td>
<td>.40</td>
<td>9</td>
</tr>
<tr>
<td>Evaluator of students' work</td>
<td>3.25</td>
<td>.62</td>
<td>8</td>
<td>3.50</td>
<td>.52</td>
<td>5</td>
</tr>
<tr>
<td>Adviser</td>
<td>3.50</td>
<td>.67</td>
<td>2</td>
<td>3.45</td>
<td>.52</td>
<td>6</td>
</tr>
<tr>
<td>Critic</td>
<td>3.09</td>
<td>.94</td>
<td>9</td>
<td>3.18</td>
<td>.40</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 8. Teacher's Behavior Pattern in Problem Solving in Technology Education. Scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree
In addition to 11 behavior patterns shown in Table 8, four out of 25 respondents in the two countries suggested the following as appropriate teacher behavior patterns for problem solving education:

(a) challenges his/her assumptions daily,
(b) serves to foster novelty and inventiveness in design,
(c) pupils need to share these roles, and
(d) serves as an enabler.

Assessment Methods of Problem Solving Competence

In relation to the assessment of problem solving in technology education, 'design portfolio' and 'self evaluation by students' were considered as the most and second most appropriate methods for assessing problem solving competence by the experts on problem solving in technology education both in the United States and in the United Kingdom.

On the other hand, the United States as well as the United Kingdom experts on problem solving ranked 'objective paper-and-pencil test' and assessment by 'competition' as the least and the second least effective assessment methods for technological problem solving in secondary education.

With respect to the format of assessment, rank order and means of eight methods for assessing problem solving competence in
technology education at the secondary level are shown in Table 9 by country.

<table>
<thead>
<tr>
<th>Assessment of Problem Solving Competence</th>
<th>UK Mean</th>
<th>UK SD</th>
<th>UK Rank Order</th>
<th>US Mean</th>
<th>US SD</th>
<th>US Rank Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral questions</td>
<td>2.85</td>
<td>.99</td>
<td>5</td>
<td>3.43</td>
<td>.65</td>
<td>3</td>
</tr>
<tr>
<td>Objective paper-and-pencil test</td>
<td>1.77</td>
<td>.73</td>
<td>8</td>
<td>2.64</td>
<td>1.01</td>
<td>8</td>
</tr>
<tr>
<td>Performance tests</td>
<td>2.92</td>
<td>.90</td>
<td>4</td>
<td>3.43</td>
<td>.65</td>
<td>3</td>
</tr>
<tr>
<td>Design portfolio</td>
<td>3.50</td>
<td>.67</td>
<td>1</td>
<td>3.86</td>
<td>.36</td>
<td>1</td>
</tr>
<tr>
<td>Checklist</td>
<td>2.64</td>
<td>.50</td>
<td>6</td>
<td>3.36</td>
<td>.50</td>
<td>5</td>
</tr>
<tr>
<td>Self evaluation by students</td>
<td>3.38</td>
<td>.51</td>
<td>2</td>
<td>3.50</td>
<td>.76</td>
<td>2</td>
</tr>
<tr>
<td>Peer evaluation</td>
<td>3.08</td>
<td>.64</td>
<td>3</td>
<td>3.29</td>
<td>.73</td>
<td>6</td>
</tr>
<tr>
<td>Competition</td>
<td>2.08</td>
<td>.76</td>
<td>7</td>
<td>3.00</td>
<td>.78</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 9. Assessment of Problem Solving Competence in Technology Education. Scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree

As shown in Table 10, criterion-referenced tests were seen as a more appropriate assessment method for problem solving in technology education than norm-referenced tests not only in the United Kingdom, but also in the United States.
Table 10. Assessment of Problem Solving Competence in Technology Education. Scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree

In relation to the time of assessment, British key experts on technological problem solving perceived that a formative evaluation, which is generally applied in the middle of instruction, as the most appropriate method for assessing problem solving competence. On the contrary, United States experts perceived a summative evaluation, which is usually applied to the end of instruction, as the most appropriate method along with formative evaluation.

On the other hand, diagnostic testing which is usually applied early in the instruction or during the instruction, was perceived as the least suitable method for assessing problem solving competence both in the United Kingdom and the United States.
With respect to the assessment methods for technological problem solving education, three out of 27 technology educators in the two countries proposed: (a) student presentation, (b) continuous assessment, and (c) market simulations.

Table 11 shows the rank order and means of diagnostic, formative, and summative evaluation by each country.

<table>
<thead>
<tr>
<th>Assessment of Problem Solving Competence</th>
<th>UK Mean</th>
<th>SD</th>
<th>Rank Order</th>
<th>US Mean</th>
<th>SD</th>
<th>Rank Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic evaluation</td>
<td>2.55</td>
<td>.93</td>
<td>3</td>
<td>2.64</td>
<td>.92</td>
<td>3</td>
</tr>
<tr>
<td>Formative evaluation</td>
<td>3.25</td>
<td>.75</td>
<td>1</td>
<td>3.31</td>
<td>.63</td>
<td>1</td>
</tr>
<tr>
<td>Summative evaluation</td>
<td>3.00</td>
<td>.43</td>
<td>2</td>
<td>3.31</td>
<td>.63</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 11. Assessment of Problem Solving Competence in Technology Education. Scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree

Proportion of Problem Solving in Technology Education

British key experts on problem solving in technology education estimated that approximately 54% was the appropriate proportion of problem solving activity to be included in a technology education program for middle school students (grade 7-9). The
United Kingdom key experts believed 59% was the appropriate proportion of problem solving activity to be included in a technology education program for high school students (grade 10-12).

On the other hand, the United States experts estimated approximately 60% and 66% as the appropriate proportion of problem solving activity to be included in a technology education program for middle school (grade 7-9) and high school (grade 10-12) students, respectively. Table 12 shows the proportion of problem solving estimated for each country.

<table>
<thead>
<tr>
<th>Proportion of problem solving</th>
<th>U K Mean(%)</th>
<th>U K SD</th>
<th>U S Mean(%)</th>
<th>U S SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Middle school (Grade 7-9)</td>
<td>54</td>
<td>10.14</td>
<td>60</td>
<td>27.20</td>
</tr>
<tr>
<td>High school (Grade 10-12)</td>
<td>59</td>
<td>15.68</td>
<td>66</td>
<td>19.32</td>
</tr>
</tbody>
</table>

Table 12. Proportion of Problem Solving in Technology Education
Degree of Agreement Between the Perceptions of British and United States Experts on Technological Problem Solving

The degree of agreement between the perceptions of United Kingdom and United States experts on problem solving in technology education is shown in Table 13 by topic of each section.

<table>
<thead>
<tr>
<th>Topic of Section</th>
<th>Spearman Coefficient (Rho)</th>
<th>Number of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals</td>
<td>.6119</td>
<td>16</td>
</tr>
<tr>
<td>Curriculum content</td>
<td>.7675</td>
<td>13</td>
</tr>
<tr>
<td>Instructional strategies</td>
<td>.7699</td>
<td>21</td>
</tr>
<tr>
<td>Teacher's role (Activity)</td>
<td>.7714</td>
<td>6</td>
</tr>
<tr>
<td>Teacher's role (Behavior pattern)</td>
<td>.7064</td>
<td>11</td>
</tr>
<tr>
<td>Assessment method (Format)</td>
<td>.8503</td>
<td>8</td>
</tr>
<tr>
<td>Assessment method (Criterion/Norm referenced)</td>
<td>1.0000</td>
<td>2</td>
</tr>
<tr>
<td>Assessment method (Time of Assessment)</td>
<td>.8660</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 13. Degree of Agreement Between the Perceptions of United Kingdom and United States Experts on Problem Solving in Technology Education
Spearman rank-order correlation (rho) shown in Table 13 were calculated from two sets of rank ordered perceptions of United Kingdom and United States experts on the first and second sections in the questionnaire. The Spearman rank-order correlation provides an indication of the degree of agreement between the United Kingdom and the United States technology educators by each section. A higher correlation coefficient would indicate a higher level of agreement between the United Kingdom and the United States experts on problem solving in technology education.

Perceptions of technology educators between the United Kingdom and the United States on assessment methods of problem solving indicated a relatively high degree of agreement on the seven questions in the questionnaire. The perceptions of the key experts on curriculum including goals, curriculum, and instructional strategies of problem solving indicated a relatively lower degree of agreement. Higher levels of agreement were found for perceptions of the appropriate methods of assessing problem solving.
CHAPTER 5

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

With the explosion of knowledge that has occurred within the past thirty years, the ability to solve problems has become more and more critical. It is not possible to teach children all the accumulated knowledge they may need, and the answers to the problems of today may not be appropriate for the problems of tomorrow. Children must learn to search for information, to formulate answers, and to create innovative solutions to new problems. They must learn to be problem solvers. (Drum & Wells, 1984, p. 1)

This chapter is composed of three sections. Section one presents a summary of the study which aims to compare problem solving in technology education at the secondary level in the United Kingdom and the United States. Section two contains conclusions which were related to the findings of the study. The last section suggests recommendations which were based on the findings and the conclusions of the study.

Summary

The purpose of this study was to compare problem solving as an integral part of technology education at the secondary level in the United Kingdom and the United States. The following areas of problem solving in technology education were identified: (1) the
way in which problem solving is defined, (2) the curriculum
goals and content of problem solving, (3) the way in which
problem solving is implemented and assessed, and (4) the
proportion of problem solving in the field of technology
education.

The design of this study was descriptive research using a
questionnaire. To achieve an understanding of problem solving in
secondary technology education in the United Kingdom and the
United States, a mail survey was used. The population of the
study, technology educators, consisted of administrators and
university professors in the field of technology education in
the two nations. Samples of the study were drawn from key
experts of technological problem solving in secondary education
in the countries. A purposive sampling procedure was employed to
select the key experts of technological problem solving.

A specialized instrument was developed based upon a review of
literature in order to clarify the concepts being studied and to
determine their suitability. In order to establish validity of
the instrument, field testing, reviewing, and assessing by a
panel experts during and after the development of the instrument
were performed. To assess reliability of the survey instrument,
the test-retest method was employed because items of the survey
instrument were not summated. The pilot test population was
different from the field test population. Both the field and
pilot test population were excluded from the actual study. The
questionnaires were mailed and collected using two methods: postal mail and e-mail.

Responses to questions of curriculum and implementation of problem solving in technology education were analyzed with the following steps:

1. Each item in the first and second sections was treated as interval data and a mean score with an accompanying standard deviation was calculated. The mean score was calculated on a four-point Likert scale with 1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree.

2. The items in the first and second sections were rank ordered by mean scores and standard deviation.

3. A Spearman rank-order correlation (rho) was calculated from two sets of rank ordered perceptions of United Kingdom and United States key experts on first and second sections in the questionnaire.

4. Responses to the definitions of technological problem solving in the third section were analyzed by content analysis. Words and themes were used as units of analysis. Trends, pattern, similarities, and differences of the definitions in the United Kingdom and the United States were described.

The following findings were based on the analysis of data collected in the study. Most frequently used concepts were 'design' and 'process' to define and explain problem solving in
technology education by the United Kingdom and United States experts. Twenty-one definitions of problem solving in technology education were categorized and grouped into five categories as follows: (a) practical success in doing and making an artifact, (b) process of resolving difficulties or dilemmas, (c) design or use of design process, (d) use or application of thought process or intellectual activity or resources, (e) application or use of knowledge, skills, and experience, and (f) transfer of knowledge.

In relation to the curriculum of problem solving, the United States technology educators perceived (a) 'develop thinking skills'; (b) 'develop planning and making skills'; and (c) 'understand and use materials, tools, and mechanisms' as the first, second, and third most important goals of problem solving in technology education at the secondary level. On the other hand, 'develop designing skills' and 'develop research and investigation skills' were perceived as the most important goals by the British experts on problem solving in technology education. Spearman rank-order correlation (rho) of problem solving goals indicates the degree of agreement between the United Kingdom and the United States technology educators was 0.61. Regarding curriculum content, technology educators both in the United States and in the United Kingdom perceived 'problem solving processes' and 'design processes' as the best and the second best pertinent curriculum contents areas of technological
problem solving in secondary education. In addition, 'control or technical systems' was perceived as the third best pertinent curriculum content of problem solving in technology education for secondary students by technology educators in both the United Kingdom and the United States. The Spearman rank-order correlation coefficient for the curriculum content of problem solving was 0.77.

With respect to instructional strategy, British technology educators preferred the following as the most appropriate instructional strategies for technological problem solving in secondary education, in rank order: (a) project or activity methods, (b) discussion, (c) brainstorming, (d) student team, and (e) field observation or field trips. United States technology educators recognized the following as the most appropriate instructional strategies, in rank order: (a) brainstorming, (b) project or activity methods, (c) student team, (d) simulation, and (e) discussion. The level of agreement between the perceptions of United Kingdom and United States technology educators on instructional strategies was higher than other sections. The Spearman rank-order correlation coefficient of the instructional strategies was 0.77.

Concerning the role of the teacher in problem solving in technology education, British technology educators recognized the following as the most suitable roles for teachers in terms of teachers' activity in technological problem solving
instruction, in rank order: (a) involves students in meaningful
dialogue, (b) provides design briefs, (c) chooses problems for
the students, and (d) provides examples and answers. In the
United States, teachers' activities ranked most suitable for
problem solving in technology education for secondary students
were: (a) involves students in meaningful dialogue, (b) provides
examples and answers, (c) provides design briefs, and (d)
chooses problems for the students.

'Serves as a facilitator' was perceived as the most appropriate
role of the teacher for problem solving instruction in terms of
behavior pattern in both the United Kingdom and the United
States. In addition, British respondents believed the following
as the second and third most appropriate behavior patterns of
the teacher for problem solving in technology education: serves
as an adviser and an expert consultant. On the other hand,
United States experts on technological problem solving believed
the following as the second and third most appropriate behavior
patterns of teacher for problem solving instruction: serves as a
source of relevant knowledge, and both as a questioning adult
and a manager of the learning situation. The Spearman rank-order
correlation ($\rho$) of perceptions between the United Kingdom and
the United States on teacher roles was 0.77 in terms of behavior
pattern and 0.71 in terms of activity.
For assessment methods of problem solving competence, 'design portfolio' and 'self evaluation by students' were considered as the most and second most appropriate methods for assessing problem solving competence by the experts in relation to assessment format of problem solving in technology education both in the United States and in the United Kingdom. In addition, criterion-referenced testing was regarded as a more appropriate assessment method for problem solving in technology education than norm-referenced tests not only in the United Kingdom, but also in the United States.

In relation to the time of assessment, British key experts on technological problem solving perceived a formative evaluation, which is generally applied in the middle of instruction, as the most appropriate method for assessing problem solving competence. On the other hand, United States experts perceived a summative evaluation, which is usually applied at the end of instruction, as the most appropriate evaluation method for problem solving accompanying formative evaluation. These findings point to philosophical difference between British and United States technology educators. The Spearman rank-order correlation coefficient of assessment methods between the United Kingdom and the United States was 0.85 in terms of format, 1.00 in terms of criterion/norm referenced, and 0.87 in terms of time of assessment.
With regards to the proportion of problem solving in technology education, British technology educators estimated that approximately 54% was the appropriate proportion of problem solving activity to be included in a technology education program for middle school students (grade 7-9) while approximately 59% was the appropriate proportion of problem solving activity to be included in a technology education program for high school students (grade 10-12). On the other hand, the United States technology educators estimated approximately 60% and 66% as the appropriate proportion of problem solving activity to be included in a technology education program for middle school (grade 7-9) and high school (grade 10-12) students, respectively.

Conclusions

The results of the study represent the collective opinion of the key experts on problem solving in technology education at the secondary level participating in the study in time and can not be constructed to be representative of any other population or situation. The conclusions which follow were an outcome of literature review and findings according to research questions of the study.

1. Much research has been done about the process of problem solving than any other facts. While British technology educators have been interested in design process, technology educators in
the United States have focused on the process of problem solving. Something common in various analyses and models of the processes is that they are complicated and perceived as not a linear process. Most of the design and problem solving processes have the common components such as (a) good problem solving statements, (b) research and development, (c) testing of solutions, (d) evaluation.

2. One universal definition of problem solving in technology education did not emerge from the respondents in the United Kingdom and United States. Problem solving was defined differently by the technology educators. However similar definitions of problem solving in technology education existed between the United Kingdom and the United States. 'Design' and 'process' were main concepts used to define and explain problem solving in technology education.

3. Perceptions of the goals of problem solving in technology education at the secondary level were perceived in different ways between the United Kingdom and the United States technology educators. British technology educators were concerned about improvement of designing and making competence in relation to the goals of problem solving while United States key experts were interested in the development of thinking capability and the practicality. On the contrary, perceptions of the curriculum content of technological problem solving in secondary education were similar between the United Kingdom and the United States.
key experts. Process consisting of consecutive steps for problem solving or designing was emphasized as a curriculum organizer of technological problem solving in both the United Kingdom and the United States.

4. There was a high level of agreement for the types of instructional strategies used for problem solving in technology education between the United Kingdom and the United States technology educators. Both British and United States technology educators preferred group problem solving strategies, rather than activity to individual problem solving activities.

5. The United States and British technology educators held similar views on the role of the teacher in problem solving in technology education at the secondary level. Technology educators in both countries viewed 'facilitating students' activity' as the major role of the teacher for technological problem solving instruction at the secondary level.

6. In understanding the appropriate assessment methods of problem solving in technology education for secondary students, similar perceptions existed between United States and United Kingdom technology educators in terms of format and criterion or norm-referenced testing. On the other hand, different perceptions were expressed of the assessment time of problem solving in technology education. British key experts on technological problem solving in secondary education believed
that formative evaluation was the most appropriate method for assessing problem solving competence while United States experts recognized summative evaluation as the most appropriate method along with formative evaluation.

7. With respect to the proportion of problem solving instruction in technology education program, a similar trend existed, in which the proportion for middle schools was lower than high schools, between perceptions of United States and United Kingdom key experts on problem solving. The United States educators' estimation of the proportion of problem solving in technology education was higher than British educators.

**Recommendations**

The recommendations which follow were based on the findings and conclusions of the study. Recommendations are also made for further study in the hopes that this study will reveal possibilities for future improvements within the technology education profession.

1. Definitions of problem solving in technology education were different for technology educators in the United States and the United Kingdom. In addition, there was confusion on the definition in the field of technology education. Further study on the reason and way of defining problem solving in technology education is needed.
2. Instructional strategies depend on the curriculum or the grade level of the target students. Appropriate instructional strategies could be different for different goals, curriculum content, or students. Therefore, more research of instructional strategies related to the these factors: goals, grade level, and curriculum content, is recommended for developing effective instruction of problem solving in technology education programs.

3. Most of the roles of teachers in problem solving instruction in technology education programs investigated in the study could be appropriate in certain contexts with particular students for the development of problem solving ability. In other words, teacher roles including activity and behavior also depend on curriculum of instruction or grade level of students. Consequently, further study of the activity and behavior patterns of teachers need to be related to the factors-- goals, grade range, and curriculum content-- for the appropriate role of teachers in problem solving instruction in technology education program.

4. The proper method for assessing problem solving competence can vary with different contexts or students. Research on appropriate assessment methods connected with the factors such as goals, curriculum content, and students is recommended for the further study.
5. Using key experts on problem solving in technology education consisting of university professors and administrators as a population was limited to identify curriculum and implementation of problem solving in technology education in this study. Therefore, further study for problem solving in education needs to focus on teachers, students, and the interaction of teachers and students in the classroom by using qualitative research including observation is recommended.
References


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APPENDIX A

Participants in The Field Test
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Department of Educational Studies
Technology Education program
The Ohio State University, Columbus, OH USA
APPENDIX B

Participants in the Piolot Test
The United Kingdom

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APPENDIX C

Participants in Survey and Their Professional Activities on Problem Solving in Technology Education
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1. Bagshaw, Mr. Howard
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2. Banks, Mr. Frank
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The School of Education, The Open University, Milton Keynes


3. Davidson, Mrs. Marian
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The School of Education, The Open University, Milton Keynes


4. Eggleston, Mr. John
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5. Harstein, Mr. Judah
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9. King, Mr. Cyril
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10. McCormick, Dr. Robert
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12. Murphy, Ms. Patricia
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   Illinois State University, Normal, IL


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   North Carolina State University, Raleigh, NC


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   Bowling Green State University, Bowling Green, OH

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6. Hutchinson, Dr. Patricia
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7. Johnson, Dr. Scott D.
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12. Todd, Dr. Ronald D.
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Trenton State College, Trenton, NJ


13. Waetjen, Dr. Walter B.
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President Emeritus of Cleveland State University.


14. Winek, Dr. Gary
School of Applied Arts and Technology, Dept. of Technology,
Southwest Texas State University, San Marcos, TX

Appendix D

Survey Instrument

(Hard copy)
Problem Solving in Technology Education at the Secondary Level in the United Kingdom and the United States

This survey is being conducted to investigate and compare the curriculum, implementation, assessment, and definition of problem solving in technology education at the secondary level in the United Kingdom and the United States. Please answer all of the questions and return it to us.

We greatly appreciate your assistance.

Sangbong Yi and Dr. Karen F. Zuga
The Ohio State University
College of Education
Technology Education program
190 West 19th Ave.
Columbus, OH 43210 USA
Fax: +(1) 614 292 2662
E-mail: sbyi@magnus.acs.ohio-state.edu
Please indicate the extent to which you agree or disagree with each item by circling one of the following letters to the right of each statement.

<table>
<thead>
<tr>
<th>SD</th>
<th>STRONGLY DISAGREE</th>
<th>D</th>
<th>DISAGREE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>AGREE</td>
<td>SA</td>
<td>STRONGLY AGREE</td>
</tr>
</tbody>
</table>

1. Statements listed below are possible goals that could be included in problem solving in technology education at the secondary level. How much do you agree or disagree with each statement as a goal of problem solving in technology education at the secondary level?

<table>
<thead>
<tr>
<th>Goal of Problem Solving</th>
<th>Level of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Explore and experience technology</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>b. Develop research and investigation skills</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>c. Develop designing skills</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>d. Develop planning and making skills</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>e. Develop thinking skills such as creative thinking, critical thinking, decision making and others</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>f. Develop ability to work independently or in teams</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>g. Evaluate existing designs or products based on given criteria</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>h. Develop an interest in safety with respect to materials, techniques and processes</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>i. Understand and use materials, tools and mechanisms</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>j. Understand and apply technological systems</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>k. Understand and apply control or technical systems</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>l. Apply experience in other subjects such as mathematics, science and art to technology education</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>m. Apply experience in technology education to practical problem or other subjects</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>n. Analyze the interaction of technology on individuals, society, and the environment</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>o. Create a deeper interest and commitment to improving the quality of life for oneself and others</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>p. Become critical of products used in everyday life</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>q. Other (Specify)</td>
<td>SD D A SA</td>
</tr>
</tbody>
</table>

Please continue on back of page
2. The following statements are possible curriculum content that could be included in problem solving in technology education at the secondary level. How much do you **agree or disagree** with each statement as curriculum content for problem solving in technology education at the secondary level?

<table>
<thead>
<tr>
<th>Curriculum Content of Problem Solving</th>
<th>Level of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Circle one)</td>
</tr>
<tr>
<td>a. Specific occupational skills of a vocational nature</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>b. Specific handicraft</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>c. Technological systems such as communication, construction, manufacturing, transportation, and others</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>d. Control or technical systems such as structural, mechanical, electrical/electronic, and pneumatic systems</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>e. Daily life, drawn from food, clothing, or shelter</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>f. Material processes such as separating, combining, and forming</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>g. Sources, properties and uses of materials such as metal, plastics, wood and others</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>h. General and specific safety in relation to materials, techniques and processes</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>i. Problem solving processes such as defining a problem, setting goals, developing alternatives, selecting the best solution, implementing the solution, and evaluating the results</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>j. Design processes including brief, investigation, ideas, developing idea(s), working drawing or model, making, and evaluation</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>k. Social concerns</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>l. Students’ interests</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>m. Influence of technology on individual, society, and environment</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>n. Other (Specify)</td>
<td>SD D A SA</td>
</tr>
</tbody>
</table>

*Please continue on back of page*
3. The following statements are possible instructional strategies for problem solving in technology education at the secondary level. How much do you agree or disagree with each statement as an appropriate instructional strategy for problem solving in technology education at the secondary level?

<table>
<thead>
<tr>
<th>Instructional Strategies of Problem Solving</th>
<th>Level of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Academic game</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>b. Brainstorming</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>c. Case study</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>d. Center of interest and display</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>e. Colloquia</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>f. Competition</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>g. Contracts</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>h. Demonstration</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>i. Discovery learning</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>j. Discussion</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>k. Field observation or field trips</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>l. Individualized instruction</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>m. Lecture</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>n. Oral reports</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>o. Project or activity methods</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>p. Protocols</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>q. Recitation</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>r. Role play</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>s. Simulations</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>t. Student teams</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>u. Tutoring</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>v. Other(Specify)</td>
<td>SD D A SA</td>
</tr>
</tbody>
</table>

Please continue on back of page

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4. The following statements are possible roles of teachers for problem solving in technology education at the secondary level. How much do you agree or disagree with each statement as an appropriate role for teachers for problem solving in technology education at the secondary level?

<table>
<thead>
<tr>
<th>Teacher's Role in Problem Solving</th>
<th>Level of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Circle one)</td>
<td>D    A    SA</td>
</tr>
<tr>
<td>a. Does not intervene</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>b. Chooses problems for the students</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>c. Involves students in meaningful dialogue</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>d. Provides examples and answers</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>e. Tightly controls activities</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>f. Provides design briefs</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>g. Other(Specify)</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>h. Serves as a facilitator</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>i. Serves as a source of relevant knowledge</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>j. Serves as an expert consultant</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>k. Serves as a manager of the learning situation</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>l. Serves as a negotiator</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>m. Serves as a questioning adult</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>n. Serves as a source of opinions, attitudes and values</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>o. Serves as an observer</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>p. Serves as an evaluator of students' work</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>q. Serves as an adviser</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>r. Serves as a critic</td>
<td>SD    D    A    SA</td>
</tr>
<tr>
<td>s. Other(Specify)</td>
<td>SD    D    A    SA</td>
</tr>
</tbody>
</table>

Please continue on back of page

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5. The following are possible methods of assessment for technological problem solving in technology education at the secondary level. How much do you agree or disagree with each statement as an assessment method of problem solving competence in technology education at the secondary level?

<table>
<thead>
<tr>
<th>Assessment of Problem Solving Competence</th>
<th>Level of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Oral questions</td>
<td>SD</td>
</tr>
<tr>
<td>b. Objective paper-and-pencil test.</td>
<td>SD</td>
</tr>
<tr>
<td>c. Performance tests</td>
<td>SD</td>
</tr>
<tr>
<td>d. Design portfolio</td>
<td>SD</td>
</tr>
<tr>
<td>e. Checklist</td>
<td>SD</td>
</tr>
<tr>
<td>f. Self evaluation by students</td>
<td>SD</td>
</tr>
<tr>
<td>g. Peer evaluation</td>
<td>SD</td>
</tr>
<tr>
<td>h. Competition</td>
<td>SD</td>
</tr>
<tr>
<td>i. Other (Specify)</td>
<td>SD</td>
</tr>
<tr>
<td>j. Criterion-referenced tests</td>
<td>SD</td>
</tr>
<tr>
<td>k. Norm-referenced tests</td>
<td>SD</td>
</tr>
<tr>
<td>l. Other (Specify)</td>
<td>SD</td>
</tr>
<tr>
<td>m. Diagnostic tests</td>
<td>SD</td>
</tr>
<tr>
<td>n. Formative evaluations</td>
<td>SD</td>
</tr>
<tr>
<td>o. Summative evaluations</td>
<td>SD</td>
</tr>
<tr>
<td>p. Other (Specify)</td>
<td>SD</td>
</tr>
</tbody>
</table>

Please answer the following question by indicating the percentage in the space provided.

6. What do you estimate as the appropriate proportion of problem solving activity to be included in a technology education program at the secondary level?

Middle school (Grade 7-9): __________ %

High school (Grade 10-12): __________ %

Please continue on back of page
7. How do you define technological problem solving or problem solving in technology education?

* We would appreciate any general comments you may concerning any aspect of problem solving in technology education.

We greatly appreciate your assistance. Thank you so much for your time and effort.
Appendix E

Survey Instrument

(E-mail version)
PROBLEM SOLVING IN TECHNOLOGY EDUCATION AT THE SECONDARY LEVEL
IN THE UNITED KINGDOM AND THE UNITED STATES

This survey is being conducted to compare the curriculum, implementation, assessment, and definition of problem solving in technology education at the secondary level in the United Kingdom and the United States. PLEASE 'REPLY' FIRST AND ANSWER ALL OF THE QUESTIONS AND RETURN IT TO US. We greatly appreciate your assistance.

Sangbong Yi and Dr. Karen F. Zuga
The Ohio State University
Technology Education program
190 West 19th Ave.
Columbus, OH 43210 USA

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Please indicate the extent to which you agree or disagree with each item by placing a slash (/) on the right of one of the following letters

SD = STRONGLY DISAGREE  D = DISAGREE
A = AGREE        SA = STRONGLY AGREE

Example:

c. Develop designing skills.......................... SD D/ A SA

---

1. Statements listed below are possible goals that could be included in problem solving in technology education at the secondary level. How much do you AGREE OR DISAGREE with each statement AS A GOAL OF PROBLEM SOLVING IN TECHNOLOGY EDUCATION at the secondary level?

<table>
<thead>
<tr>
<th>Goals of Problem Solving</th>
<th>Level of Agreement (Mark one)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Explore and experience technology.............................</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>b. Develop research and investigation skills...................</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>c. Develop designing skills.........................................</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>d. Develop planning and making skills............................</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>e. Develop thinking skills such as creative thinking, critical thinking, decision making and others...</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>f. Develop ability to work independently or in teams..........</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>g. Evaluate existing designs or products based on given criteria</td>
<td>SD D A SA</td>
</tr>
</tbody>
</table>
h. Develop an interest in safety with respect to materials, techniques and processes..............SD D A SA
i. Understand and use materials, tools and mechanisms........SD D A SA
j. Understand and apply technological systems...............SD D A SA
k. Understand and apply control or technical systems......SD D A SA
l. Apply experience in other subjects such as art mathematics and science to technology education.........SD D A SA
m. Apply experience in technology education to practical problem or other subjects..........................SD D A SA
n. Analyze the interaction of technology on individuals, society, and the environment.........................SD D A SA
o. Create a deeper interest and commitment to improving the quality of life for oneself and others..........SD D A SA
q. Become critical of products used in everyday life....SD D A SA
r. Other (Specify) ..........................................................SD D A SA

2. The following statements are possible curriculum content that could be included in problem solving in technology education at the secondary level. How much do you AGREE OR DISAGREE with each statement AS CURRICULUM CONTENT FOR PROBLEM SOLVING IN TECHNOLOGY EDUCATION at the secondary level?

Curriculum Content of Problem Solving

Lev el of Agreement

(Mark one)

a. Specific occupational skills of a vocational nature...SD D A SA
b. Specific handicraft..................................................SD D A SA
c. Technological systems such as communication, construction, manufacturing, transportation, and others........SD D A SA
d. Control or technical systems such as structural, mechanical, electrical/electronic, and pneumatic systems........SD D A SA
e. Daily life, drawn from food, clothing, or shelter.....SD D A SA
f. Material processes such as separating, combining, and forming....................................................SD D A SA
g. Sources, properties and uses of materials such as metal, plastics, wood and others.........................SD D A SA
h. General and specific safety in relation to materials, techniques and processes.............................SD D A SA
i. Problem solving processes such as defining a problem, setting goals, developing alternatives, selecting the best solution, implementing the solution, and evaluating the results. ........................................ SD  D  A  SA

j. Design processes including brief, investigation, ideas, developing idea(s), working drawing or model, making, and evaluation........................................ SD  D  A  SA

k. Social concerns................................................................................................................. SA  D  A  SA

l. Students’ interests............................................................................................................... SA  D  A  SA

m. Influences of technology on individuals, society, and environment........................................ SD  D  A  SA

n. Other (Specify) ................................................................................................................. SD  D  A  SA

3. The following statements are possible instructional strategies for problem solving in technology education at the secondary level. How much do you AGREE OR DISAGREE with each statement AS AN APPROPRIATE INSTRUCTIONAL STRATEGY FOR PROBLEM SOLVING IN TECHNOLOGY EDUCATION at the secondary level?

Instructional Strategies of Problem Solving

<table>
<thead>
<tr>
<th>Instructional Strategies of Problem Solving</th>
<th>Level of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Academic game........................................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>b. Brainstorming........................................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>c. Case study................................................................................ SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>d. Center of interest and display............................................. SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>e. Colloquia.................................................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>f. Competition................................................................................ SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>g. Contracts.................................................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>h. Demonstration............................................................................ SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>i. Discovery learning................................................................. SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>j. Discussion................................................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>k. Field observation or field trips............................................. SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>l. Individualized instruction...................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>m. Lecture........................................................................................ SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>n. Oral reports............................................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>o. Project or activity methods.................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>p. Protocols.................................................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>q. Recitation.................................................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>r. Role play..................................................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>s. Simulations............................................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>t. Student teams............................................................................ SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>u. Tutoring..................................................................................... SD  D  A  SA</td>
<td></td>
</tr>
<tr>
<td>v. Other (Specify)......................................................................... SD  D  A  SA</td>
<td></td>
</tr>
</tbody>
</table>
4. The following statements are possible roles of teachers for problem solving in technology education at the secondary level. How much do you AGREE OR DISAGREE with each statement AS AN APPROPRIATE ROLE OF TEACHERS for PROBLEM SOLVING IN TECHNOLOGY EDUCATION at the secondary level?

<table>
<thead>
<tr>
<th>Teacher's Role in Problem Solving</th>
<th>Level of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Does not intervene</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>b. Chooses problems for the students</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>c. Involves students in meaningful dialogue</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>d. Provides examples and answers</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>e. Tightly controls activities</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>f. Provides design briefs</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>g. Other(Specify)</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>h. Serves as a facilitator</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>i. Serves as a source of relevant knowledge</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>j. Serves as an expert consultant</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>k. Serves as a manager of the learning situation</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>l. Serves as a negotiator</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>m. Serves as a questioning adult</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>n. Serves as a source of opinions, attitudes and values</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>o. Serves as an observer</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>p. Serves as an evaluator of students' work</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>q. Serves as an adviser</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>r. Serves as a critic</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>s. Other(Specify)</td>
<td>SD D A SA</td>
</tr>
</tbody>
</table>

5. The following are possible assessment methods for problem solving in technology education at the secondary level. How much do you AGREE OR DISAGREE with each statement AS AN ASSESSMENT METHOD OF PROBLEM SOLVING COMPETENCE IN TECHNOLOGY EDUCATION at the secondary level?

<table>
<thead>
<tr>
<th>Assessment Methods of Problem Solving Competence</th>
<th>Level of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Oral questions</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>b. Objective paper-and-pencil test</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>c. Performance tests</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>d. Design portfolio</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>e. Checklist</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>f. Self evaluation by students</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>g. Peer evaluation</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>h. Competition</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>i. Other(Specify)</td>
<td>SD D A SA</td>
</tr>
<tr>
<td>j. Criterion-referenced test</td>
<td>SD D A SA</td>
</tr>
</tbody>
</table>
Please indicate the percentage in the parentheses.

6. What do you estimate as the APPROPRIATE PROPORTION OF PROBLEM SOLVING ACTIVITY to be included in a TECHNOLOGY EDUCATION PROGRAM at the secondary level?

Middle school (Grade 7-9) ( )%  
High school (Grade 10-12) ( )%

Please write your response, using as much space as you need.

7. How do you DEFINE PROBLEM SOLVING IN TECHNOLOGY EDUCATION or TECHNOLOGICAL PROBLEM SOLVING?

"We would appreciate any general comments you may concerning any aspect of problem solving in technology education.

Thank you so much for your time and effort."
Appendix F

Letter to Field Test Participants
May 15, 1996

Dr. Michael L. Scott  
The Ohio State University  
Dept. Educational Studies  
Technology Education program  
190 West 19th Ave.  
Columbus, OH 43210

Dear Dr. Michael Scott:

Recognizing that this is a busy time in your school calendar, I respectfully request your assistance in field testing a survey instrument for a doctoral dissertation study. The study is conducted to investigate and compare technological problem solving in secondary education as perceived by expert in the United Kingdom and the United States. You have been selected to help field test the survey instrument for wording, clarity, content and format. I am conducting this study in cooperation with The Ohio State University, Department of Educational Studies: Technology Education Program.

Enclosed are the survey instrument and a feedback form for providing input. Your feedback will be used to revise questionnaire before it is administrated to experts of technological problem solving in the United Kingdom and the United States. I greatly appreciate if you return the feedback form and questionnaire by May 25, 1996.

Your input will be used solely for improving the survey instrument. Your name will not be placed on the instrument nor reported in the study results.

If you have any questions, do not hesitate contact me by e-mail at sbyi@magnus.acs.ohio-state.edu. I greatly appreciate your assistance.

Sincerely,

[Signature]

Sangbong Yi  
Ph. D. Candidate

Karen F. Zuga, Ph.D.  
Associate Professor  
Technology Education
Survey Instrument Feedback Form

The Survey of Technological Problem Solving in Secondary Education in the United Kingdom and the United States

Field Test Input

Instructions:

Please read the survey instrument in its entirety. Evaluate the directions and corresponding items in each section for wording, clarity and content. Identify invalid items and unclear statements in the spaces provided on the feedback form. Additional comments and suggestions regarding the contents, format, appearance and length of the survey are appreciated. You may use the space labeled “Additional Comments”

Your professional input into the validity and refinement of this survey instrument is appreciated. Thank you very much for your time and effort.

Question 1: Goals of Technological Problem solving

Unclear directions: ____________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________
Unclear Statements:

Invalid statements:

Additional comments:

**Question 2: Curriculum Contents of Technological Problem solving**

Unclear directions:

Unclear Statements:
Invalid statements: ____________________________
________________________________________
________________________________________
________________________________________
________________________________________

Additional comments: ____________________________
________________________________________
________________________________________
________________________________________

Question 3: Instructional Strategy of Technological Problem solving

Unclear directions: ____________________________
________________________________________
________________________________________
________________________________________

Unclear Statements: ____________________________
________________________________________
________________________________________
________________________________________

Invalid statements: ____________________________
________________________________________
________________________________________
Question 4: Teacher’s Role of Technological Problem solving

Unclear directions:


Unclear Statements:


Invalid statements:


Additional comments:
Question 5: Assessment Methods of Technological Problem solving

Unclear directions: __________________________________________________________

______________________________________________________________

______________________________________________________________

Unclear Statements: ______________________________________________________

______________________________________________________________

______________________________________________________________

Invalid statements: ______________________________________________________

______________________________________________________________

______________________________________________________________

Additional comments: ____________________________________________________

______________________________________________________________

______________________________________________________________

Question 6: Proportion to problem Solving to be in a Technology Education

Unclear directions: ______________________________________________________

______________________________________________________________

______________________________________________________________

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Unclear Statements: ________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

Invalid statements: ______________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Additional comments: ____________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Question 7: Definition of Technological Problem solving

Unclear directions: ________________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________

Unclear Statements: _____________________________________________
________________________________________________________________
________________________________________________________________
________________________________________________________________
Invalid statements: 

Additional comments:
Appendix G

Letters to Pilot Test participants
June 2, 1996

Mrs. Marian Davidson  
The Open University  
School of Education  
Walton Hall,  
Milton Keynes, MK7 6AA, UK

Dear Mrs. Marian Davidson

I request your help in pilot testing a survey instrument for a dissertation study. I am conducting this study to compare technological problem solving in the United Kingdom and the United States. You were identified as an expert who understands technological problem solving in secondary school curriculum.

I would appreciate you taking a few minutes to complete the enclosed questionnaire. To assess the reliability of the survey instrument, the test-retest method is employed. I will need your help to complete the questionnaire again next week.

Please complete and return the questionnaire by June 14, 1996. For quick communication, may I suggest you respond by fax at +(1) 614 292-2662?. If you are using e-mail, please let me know your e-mail address through my e-mail at ‘sbyi@magnus.acs.ohio-state.edu’. I can send this and the second questionnaire by e-mail. You may also reply to the e-mail message that I send.

Your input will be used to establish the reliability of my survey instrument. I have enclosed a token of appreciation in return for your assistance. You will also receive an abstract of the results of the survey once the research has been completed.

Thank you very much for your assistance in this study. If you have any questions, do not hesitate to contact me. I greatly appreciate your assistance.

Sincerely,

Sangbong Yi  
Ph. D. Candidate

Karen F. Zuga, Ph.D.  
Associate Professor  
Technology Education Program

Ph. D. Candidate
Dr. Ernest Savage  
Visual Communication and Technology Education Dept.  
College of Technology  
Bowling Green State University  
Bowling Green, OH 43403-0300

Dear Dr. Ernest Savage,

Several days ago, I requested your help in pilot testing a survey instrument for a dissertation study by e-mail. I am conducting this study to investigate and compare technological problem solving in the United Kingdom and the United States. You were identified as an expert who understands technological problem solving in secondary school curriculum.

If you have already completed and returned the questionnaire to us, please accept our sincere thanks. If not, would you please take a few minutes to do so now? You can return your response by replying to the e-mail message. Your input is invaluable in establishing the reliability of my survey instrument.

Enclosed is a token of appreciation for your assistance. You will also receive an abstract of the results of the survey once the research has been completed.

Thank you very much for your assistance in this study. If you have any questions, do not hesitate to contact me. I greatly appreciate your assistance.

Sincerely,

Sangbong Yi  
Ph. D. Candidate

Karen F. Zuga, Ph.D.  
Associate Professor  
Technology Education Program
Dear Dr. Ralph Borchers

I request your help in pilot testing a survey instrument for a dissertation study. I am conducting this study to investigate and compare technological problem solving in the United Kingdom and the United States. You were identified as an expert who understands technological problem solving in secondary school curriculum.

I would appreciate you taking a few minutes to complete the following questionnaire. To assess the reliability of the survey instrument, the test-retest method is employed. I will need your help to complete the questionnaire again next week.

Please complete and return the questionnaire by replying to next two e-mail messages by June 12 1996. Your input is invaluable in establishing the reliability of my survey instrument.

By surface mail, I sent you a token of appreciation for your assistance. You will also receive an abstract of the results of the survey once the research has been completed.

Thank you very much for your assistance in this study. If you have any questions, do not hesitate to contact me. I greatly appreciate your assistance.

Sincerely,

Sangbong Yi
Ph. D. Candidate

Karen F. Zuga, Ph.D.
Associate Professor
Technology Education Program
June 16, 1996

Dr. Loren Martin  
College of Engineering and Technology  
Technology Education & Construction Management Dept.  
230 Snell Building  
Brigham Young University  
Provo, UT 84602

Dear, Dr. Loren Martin

A couple of weeks ago, I requested your help in pilot testing a survey instrument for a dissertation study by e-mail. I am conducting this study to investigate and compare technological problem solving in the United Kingdom and the United States. You were identified as an expert who understands problem solving in technology education.

If you have already completed and returned the questionnaire to me, please accept my sincere thanks. If not, would you please take a few minutes to do so now? Please check your e-mail. You can return your response by replying to the e-mail message that I sent. Your input is invaluable in establishing the reliability of my survey instrument. Thank you very much for your assistance in this study. If you have any questions, do not hesitate to contact me.

Sincerely,

Sangbong Yi  
Ph. D. Candidate
June 16, 1996

Dr. John A. Zaner
Dept. of Technology
School of Applied Science
University of Southern Maine,
37 College Ave.
Gorham, ME 04038

Dear Dr. John Zaner

A couple of weeks ago, I requested your help in pilot testing a survey instrument for a dissertation study. I am conducting this study to investigate and compare technological problem solving in the United Kingdom and the United States. You were identified as an expert who understands problem solving in technology education.

If you have already completed and returned the questionnaire to me, please accept my sincere thanks. If not, would you please take a few minutes to do so now? For quick communication, may I suggest you respond by fax at +(1) 614 292-2662?. If you are using e-mail, please let me know your e-mail address through my e-mail at 'sbyi@magnus.acs.ohio-state.edu'. I can send the questionnaire by e-mail. You may also reply to the e-mail message that I send. Your input is invaluable in establishing the reliability of my survey instrument. If you have any questions, do not hesitate to contact me. I greatly appreciate your assistance.

Sincerely,

Sangbong Yi
Ph. D. Candidate
Dear Dr. Ralph E. Borchers,

Thank you so much for the response to the first pilot test. I greatly appreciate your time and effort. As I mentioned earlier, I need your help one more time to complete the questionnaire again because the test-retest method is employed to assess the reliability of the survey instrument.

I would appreciate it if you can spend few minutes to complete the following questionnaire again. Please complete and return the questionnaire by replying to next e-mail message by July 12, 1996. Your input is invaluable in establishing the reliability of my survey instrument.

You will receive an abstract of the results of the survey once the research has been completed. If you have any questions, do not hesitate to contact me. I greatly appreciate your assistance in this study.

Sincerely,

Sangbong Yi
Ph. D. Candidate

Karen F. Zuga, Ph.D.
Associate Professor
Technology Education Program
Appendix H

Letters to the Survey Participants
July 1, 1996

Dr. Karen R. Todd
Montclair State University
Department of Home economics
Valley Road & Normal Ave.
Upper Montclair, NJ 07043

Dear Dr. Karen R. Todd,

We wish to request your help in a survey for a dissertation study. Sangbong Yi is conducting this study to investigate and compare problem solving in technology education at the secondary level in the United Kingdom and the United States. You were identified as an expert who understands problem solving in technology education at the secondary level.

We would appreciate you taking a few minutes to complete the enclosed questionnaire. Please complete and return the questionnaire in the enclosed envelope. You may also respond by fax at 614 292-2662. Please mail or fax your response by July 15, 1996. If you are using e-mail, please let Sangbong know your e-mail address through his e-mail at ‘sbyi@magnus.acs.ohio-state.edu’. He could then send the instrument by e-mail. You may then respond by e-mail to the message that he will send.

We have enclosed a token of appreciation in return for your assistance. You will also receive an abstract of the results of the survey once the research has been completed.

If you have any questions, do not hesitate to contact us. We eagerly look forward to your response. We greatly appreciate your assistance.

Sincerely,

Sangbong Yi
Ph. D. Candidate

Karen F. Zuga, Ph.D.
Associate Professor
Technology Education Program

174
July 1, 1996

Professor George Mills
University of Strathclyde
Jordanhill Campus,
76 Southbrae Dr.
Glasgow, G13 1PP UK

Dear Professor George Mills

We wish to request your help in a survey for a dissertation study. Sangbong Yi is conducting this study to compare problem solving in technology education at the secondary level in the United Kingdom and the United States. You were identified as an expert who understands problem solving in technology education at the secondary level.

We would appreciate you taking a few minutes to complete the enclosed questionnaire. Kindly complete and return the questionnaire by July 15, 1996. For quick communication, may we suggest you respond by fax at +(1) 614 292-2662?. If you are using e-mail, please let Sangbong know your e-mail address through his e-mail at 'sbyi@magnus.acs.ohio-state.edu'. He can send the questionnaire by e-mail. You may also reply to the e-mail message that he will send.

We have enclosed a token of appreciation in return for your assistance. You will also receive an abstract of the results of the survey once the research has been completed. If you have any questions, do not hesitate to contact us. We eagerly look forward to your response. We greatly appreciate your assistance.

Sincerely,

Sangbong Yi
Ph. D. Candidate

Karen F. Zuga, Ph.D.
Associate Professor
Technology Education Program
July 1, 1996

Dr. Phil Roberts
Dept. of Design and Technology,
Loughborough University of Technology
Loughborough,
Leicestershire LE11 3TU United Kingdom

Dear Dr. Phil Roberts,

Several days ago, we requested your help in a survey for a dissertation study by e-mail. Sangbong Yi is conducting this study to investigate and compare problem solving in technology education at the secondary level in the United Kingdom and the United States. You were identified as an expert who understands problem solving in technology education at the secondary level.

If you have already completed and returned the questionnaire to us, please accept our sincere thanks. If not, would you please take a few minutes to do so now? You can respond by replying to the e-mail message that Sangbong sent. For quick communication, we prefer that you reply by e-mail, but you may respond to the enclosed questionnaire by fax at +(1) 614 292-2662. Your input is invaluable in the dissertation study.

Enclosed is a token of appreciation for your assistance. You will also receive an abstract of the results of the survey once the research has been completed. Thank you very much for your assistance in this study. If you have any questions, do not hesitate to contact us.

Sincerely,

Sangbong Yi
Ph. D. Candidate

Karen F. Zuga, Ph.D.
Associate Professor
Technology Education Program
Dr. Gary Winek  
Southwest Texas State University  
School of Applied Arts and Technology  
Dept. of Technology  
San Marcos, TX 78666

Dear Dr. Gary Winek  

Several days ago, we requested your help in a survey for a dissertation study by e-mail. Sangbong Yi is conducting this study to investigate and compare problem solving in technology education at the secondary level in the United Kingdom and the United States. You were identified as an expert who understands problem solving in technology education at the secondary level.

If you have already completed and returned the questionnaire to us, please accept our sincere thanks. If not, would you please take a few minutes to do so now? You can respond by replying to the e-mail message that Sangbong sent. For quick communication, we prefer that you reply by e-mail, but you may also complete and return enclosed questionnaire using the enclosed envelope. Your input is invaluable in the dissertation study.

Enclosed is a token of appreciation for your assistance. You will also receive an abstract of the results of the survey once the research has been completed. Thank you very much for your assistance in this study. If you have any questions, do not hesitate to contact us.

Sincerely,

Sangbong Yi  
Ph. D. Candidate

Karen F. Zuga, Ph.D.  
Associate Professor  
Technology Education Program

July 1, 1996
To: boser@indtech.it.il
From: sbyi@magnus.acs.ohio-state.edu (Sangbong Yi)
Subject: Requesting your help in a survey

Dr. Richard A. Boser
210 Turner Hall
Dept. of Industrial Technology
Illinois State University
Normal, Illinois 61790-5100

Dear Dr. Richard A. Boser,

We wish to request your help in a survey for a dissertation study. Sangbong Yi is conducting this study to investigate and compare problem solving in technology education at the secondary level in the United Kingdom and the United States. You were identified as an expert who understands problem solving in technology education at the secondary level.

We would appreciate you taking a few minutes to complete the following questionnaire. Kindly reply to this e-mail message by July 15 1996. Your input is invaluable in the dissertation study.

By postal mail, we sent you a token of appreciation for your assistance. You will also receive an abstract of the results of the survey once the research has been completed.

If you have any questions, do not hesitate to contact us. We eagerly look forward to your response. We greatly appreciate your assistance.

Sincerely,

Sangbong Yi
Ph. D. Candidate

Karen F. Zuga, Ph.D.
Associate Professor
Technology Education Program
Ms. Patricia Murphy  
Center for Curriculum & Teaching Studies  
The School of Education  
The Open University  
Milton Keynes, United Kingdom

Dear Ms. Patricia Murphy,

Several weeks ago, we requested your help in a survey for a dissertation study of problem solving in technology education in the United Kingdom and the United States.

If you have already completed and returned the questionnaire to us, please accept our sincere thanks. If not, would you please take a few minutes to do so now? We are requesting your help again because of the significance each questionnaire has to the usefulness of this study. Please check your e-mail and reply to the e-mail message that Sangbong sent. You may also send your response by fax at +1 614-292-2662. We would greatly appreciate if you respond as soon as possible.

We eagerly look forward to your response. Enclosed is another copy of the questionnaire in case you lost or misplaced the original. We greatly appreciate your assistance in the study.

Sincerely,

Sangbong Yi  
Ph. D. Candidate

Karen F. Zuga, Ph.D.  
Associate Professor  
Technology Education Program
To: lhatc@bgnet.bgsu.edu
From: sbyi@magnus.acs.ohio-state.edu (Sangbong Yi)
Subject: I am still looking forward to your response.

Dear Dr. Larry Hatch,

Several weeks ago, I requested your help in a survey for a dissertation study of problem solving in technology education in UK and US.

To this date, I have not received your response. I am requesting your help again because of the significance each questionnaire has to the usefulness of this study. I would greatly appreciate you taking a few minutes to complete the following questionnaire. Kindly reply to following e-mail message as soon as possible. Your response is invaluable in the dissertation study.

If you have any questions, do not hesitate to contact me. I eagerly look forward to your response. The following is another copy of the questionnaire in case you lost or misplaced the original. I greatly appreciate your assistance in the study.

Sincerely,
Sangbong Yi
Appendix I

Definitions of Problem Solving in Technology Education
From Respondents in the United Kingdom

1. Difficult to define on its own. However, within the context of a technology education curriculum (whatever that is precisely) the problem solving is principally of practical nature.

Technology itself is essentially pragmatic in nature since its ultimate measure of success is the satisfaction of human needs and wants, and identified market opportunities. Technology includes those design activities which strive for technical excellence in terms of function, safety, reliability, quality, efficiency and economy.

In endeavoring to satisfy, through technology, human needs and wants, and identified market opportunities, technology activities involves the solving of practical problems which employ particular intellectual and physical resources in their resolution.

2. Problem solving in this context is the process by which students are encouraged to evolve a solution to a contextual situation using a selection from a set of available resources in an intelligent and creative manner. The process deals as much with the analysis of the problem as it does with the design and implementation of the solution.
3. It is necessary to decide who define the problem and whether it is an open or closed problem. Novice students need problems that are reasonably well defined, small scale and soluble. The problem solving here is a means of developing strategies for thinking about how to tackle a problem and to acquire the necessary doing and making skills. The problems can be chosen with these skills in mind. With experience, the problems can be capable of a range of different solutions and the problems may be chosen by the students. Experience suggests however that a tightly drawn brief with specific outcomes intended will lead to better quality work than something which is vague or broad. It would be worth looking at how some of the UK Technology curriculum projects address these issues, e.g. the Nuffield Technology project materials published by Addison-Wesley-Longman.

4. I have used the idea of Capability Tasks as technological problem solving activity throughout this questionnaire. This is setting a whole problem within a context by negotiation with the student. They work to solve that particular general task. Within that activity there will be a needed for Resource Tasks of different kinds to help the student with aspects of knowledge or procedures which they will need to solve the task. This would be built into the programme or may be on a as-needed basis if the student follows an unusual line of development. For example, the student may wish to solve the problem of an alarm for a blind person to tell whether a cup of hot drink is full as they pour
it out. The capability task would be the design of an alarm for the disabled and the negotiated problem the one I have just identified. Resource tasks would be a case study of existing products; a resource tasks of investigating simple switching circuits; a resource tasks of techniques for packing simple electric elements including the battery and how one would change it.

Open ended "problem solving" with children being given knowledge ONLY on an as-needed basis is frustrating for the pupil and leads to poor quality work. Problem-solving in technology must be more than allowing them to use their "common sense" they need help and support to expose them to useful procedures and processes.

5. Faced with a task which the students have some ownership, they are taught appropriate knowledge and skills to allow them to tackle the problem. Based on their developing experience, students investigate the problem, singly or in groups. They take into account the resources available to them and the effect that various solutions may have on the environment and on other people. They should constantly evaluate their thinking, reflecting on their progress, identifying possible routes forward. And they should produce a solution to their problem, evaluate its success against the initial criteria.

6. With difficulty, our research work has shown a variety of approaches by teachers including PS as success in making an
artifact which meets the design brief PS, as the use of the steps of the design process, and PS as successful resolution of difficulties or dilemmas that arise during the task set by the brief. Generally the students adhere to the 3rd of these. Our situated cognition perspective requires the task to be authentic if problem solving is to take place.

7. An adoptive and flexible ongoing process of resolving genuine dilemmas.

8. The creative use of knowledge, skills and experience to produce technique, tools and items that people need.
From Respondents in the United States

1. The application of a systematic thought process to seek and apply solutions to technological needs.

2. Problem-solving (with a capital P) describes the reason technology has evolved—because human beings have had to overcome problems to continue to exist. The lower-case version of problem-solving is what the laboratory researchers see when they study rats in mazes: overcoming obstacles to get what you want. In neither case is a specific process implied.

3. The process of developing appropriate solutions to opportunities or problems.

4. Technological problem solving or technological design is one of many unique forms of rational human activity used to accomplish desired goals (others include but are not limited to ethical decision making, scientific inquiry, artistic expression, and historical research). Technological design is the planned process of technological change. Instead of something changing by accident (or natural processes), design demands that we plan change so that we end up with the results we want. It also means that we attempt to minimize trade-offs and control risk. Technology is all about design.
5. Application of knowledge and skills to manipulate and control our technological environment.

6. The technological problem solving concerns all these human intellectual activities associated with unknown in a technological equation. The problem solving in technology education concerns all these human intellectual activities associated with unknown in the field of technology education. Unless these are unknowns there are no problems, only answers.

7. I don’t think there is one universal definition. I would categorize technological problem solving into several areas including design and problem solving, production type problem solving (problems that occur while new designs are being tested and produced), and service problem solving (maintenance and repair type problems). The contextual differences between these three problem types are important and seem to influence the problem solving processes that are used.

8. Using technical means (tools, material, etc.) to solve social and cultural problems.

9. The process by which knowledge is applied to identifying, selecting and creating solutions to problems resulting in improved or new products, systems and environments.
10. Design and problem solving is the translation of ideas into a tangible product, system or environment. It provides a plan that includes how to make, test and improve the proposed and implemented design.

11. Technical problem solving is a process of applying technical, social, cultural, political and/or economic solutions to an identified technical problem for the benefit of society.

12. Technological problem solving is solving the same type of problems in the same manner that a technologist experiences. In short, it's solving problems and creating new knowledge as done by a technologist.

13. Problem solving is not a very useful term for technology education as there are many curriculum areas engaged in too many different kinds of activities described as "problem solving." The term has been trivialized, and it would be more useful to attempt to define a little used or new term than to redefine problem-solving.

What you seem to be eluding to might be better called "design-based activity" or something similar. Design would be a more useful "umbrella" term under which "problem-solving" of all kinds take place; "design" implies purpose and choice; weighing consequences of one's actions.
"Problem-solving" implies finding a solution - any solution, just get the job done. In technology education, I would like my students to do the former -- the latter has brought us pollution and other environmental problems.

David Barlex, one of the directors of the Nuffield Project in Britain, described two types of student activities: resourcing activities, where the primary focus is on gaining new knowledge, skills, etc.; and capability activities, where the primary focus is on students applying knowledge through design-based activity. In well-developed design-based activities, students apply knowledge learned as well as extend that knowledge.

Designing (problem solving?) does not take place in a vacuum. The designer must have appropriate technical knowledge to achieve an appropriate solution. Organizing technological knowledge for design work means that students should see the transferrability of knowledge; for example, understanding the common elements of structures would make that knowledge applicable to designing a chair, shed, playground sliding board, etc.
Appendix J

Comments from Respondents
1. I found this questionnaire difficult to fill in as I would wish to use all the range of pedagogic strategies to teach problem solving to specific pupils at specific times. A certain student, for example, might need very direct and close instruction to help with a particular technique within a general capability task or “project”. You may wish to question the widely held assumption (de Bono for example) that problem solving is transferable between domains. At the open University Prof. Bob McCormick and Patricia Murphy are doing a lot of work which questions this. You may wish to read: Hennesy, S and McCormick R (1994) ‘problem Solving in Technology: Myth or Reality’ in Bank, F (ed.) Teaching Technology, London, Routledge.

PS Thanks for the tea bag.

2. I don’t believe that problem solving should be divorced from the many other aspects that make up technology education. In the UK we appeared to go too far towards problem solving being an ideal in its own right. It has proved most successful when students are involved in tasks which require them to solve problems, but where there are also opportunities for the teacher to intervene, to teach, to extend the student’s knowledge. But perhaps key is the nature of the tasks which students attempt, they should be challenging to the students, but within their
capabilities. They need to interest and motivate and seem relevant to the students.

3. For me, technology education is the key to understanding of the contemporary world, to living successfully in it and to participating in its future. Accordingly it is an essential component of intellectual, moral, emotional and social developments of all young people. Perhaps its too big just to be left to technology educators. Thanks for an interesting exercise! good luck with your study!

4. I assume you are familiar with our work. These are two papers from AERA 1996 which would be of interest and further papers on collaboration and p.s. to come. If you would like a publications list or recent papers please fax J. Whild the PSTE secretary.

5. The view of problem solving here is very narrow- see our paper for more detail of what we’ve observed and have we construe it.

The question (about appropriate proportion of problem solving activity to be included in a technology education) is a nonsense as problem solving is involved in all aspects of technology whether deliberately tested or not.

6. (about appropriate instructional strategies for problem solving in technology education) They all have their role, so I
cannot rate them, and if I did it could reflect a general view of the strategy.

7. Strategy for teaching technology

To be successful in tackling problems of design and construction to meet a particular need, a sound method is required. Technologists call this the 'design process'.

The design process can be simplified into a routine five basic steps that the pupils can learn to follow.

A. Think. Identify the problems: see what is needed; collect and assess ideas.
B. Design. Select the best ideas and draw, plan, specify clearly something which might solve the problem or produce what is required.
C. Make. Build or make something to your design.
D. Test. Test the technique or items you have produced to see if it is successful.
E. Improve. Redesign, alter, rebuild or modify what you have produced in an attempt to get the best possible results.

Variations of the process described are possible and often desirable. The crucial message, however, is that teachers must get across to pupils is the general spirit of the design process.
From Respondents in the United States

1. problem solving is a slippery issue. There are many types of problem solving from discovery activities, to trouble shooting, to R & D. In Tech. Ed., we use the term very loosely and generally mean problem solving activities given to students to aquatint them with technological concepts and content. I believe that the British have a much more focused meaning for problem solving based on the tangible outcomes and mental processes implicit in product design. No judgment here, just an observation of differences. I would be interested in a summary of your results. Good luck in your study.

2. I am very interested in the topic you’re exploring, but I’ve had some problems with the questionnaire. I did my dissertation on “Problem-Solving in British Technology Education” about ten years ago, as you probably know. At that time I used the term problem-solving to mean design. It caused a lot of confusion, because educational psychologists and people investigating the possibilities of artificial intelligence had pretty well co-opted the term “problem-solving,” and it had very little to do with what I meant. (I had been advised not to use the term “design” because it would connote things that the profession would neither understand nor respect).

Time has moved on, and we now see people in the profession talking about design, if reluctantly. So I would suggest a need
to define terms here. As is so typical of a lot of our terminology, there seem to be both a large scale use of the terms design and problem-solving. (The same is true of technology.)

For me, Problem-solving (with a capital P) describes the reason technology has evolved—because human beings have had to overcome problems to continue to exist. The lower-case version of problem-solving is what the laboratory researchers see when they study rats in mazes: overcoming obstacles to get what you want. In neither case is a specific process implied.

On the other hand, Design (big D) is the idea of using intellect to develop a plan for achieving a goal or goals. If you don't make decisions and take purposeful action, then you live by default. The process of design includes a number of techniques and strategies that can be learned and that ultimately let you proceed toward a goal.

I don't mean this to be a dissertation in itself, and I know that at this point, what you want is data. I hope that understanding my perspective will make my input useful to you.

#1. I've paraphrased the question: "Why would you use design activity in a technology education program" If that's not really the question, please disregard my answers.
#2. To enable me to answer this, I changed “could be included in problem solving in technology education” to “could be delivered through design activity in technology education.” Some of this doesn’t strike me as content. Some items are more like “context,” some are perspectives (valuable when contrasted to other perspectives, and some (like occupational skills) would take so long to develop that they would preclude learning about the larger picture of technology, designing, and the issue related to both.

#3. I would rule out few instructional strategies as possible. It depends on the scenario. Some highly traditional activities have been used the wrong way in my opinion (often as stand-alones or non-sensical ends-in-themselves), but are great for setting a stage, information gathering. Contracts, for instance, can be used to teach time management to individuals who have trouble with organization and meeting deadlines.

#4. When we talk about possible role of a design-oriented technology teacher, nothing is impossible. I have taken every one of these roles, sometimes successfully and sometimes unsuccessfully for the occasion.

I envision the teacher as the ultimate designer of the students’ learning experience. Sometimes I need to set the stage. Sometimes I’m seeing to practical skills. Sometimes I need to intervene, guide and correct. My greatest pleasure is in sensing that the designing has picked up momentum of its own and then I
can sit back, observe and reflect on how I might improve upon this activity, adjust my goals, etc.

3. We . . . as technology educators . . . often 'do' problem solving activities in our programs------ but we don't teach problem solving. It's a major issue in curriculum design and implementation.

4. This is a topic that has received considerable attention by various individuals in the field of technology education over the years. I believe most of the work in the field has been wide of the mark with respect to technology because those involved have not studied and worked with those in the technologies that are directly involved on a daily basis in technological work and thus "problem solving."

(about appropriate roles for teachers for problem solving in technology education) These all depend on the goals of instruction. My role, your role, the role we "play" depends on the goal of instruction. If we want to observe problem solving relating to mass confusion we place the students in an empty room and instruct them to "do something".

5. I am particularly interested in seeing that students apply their work in daily, personal and community context. That they are involved with issues in the near environment as a springboard for developing understanding and skills related to the large political, economic, social and physical systems. Also
I hope we stress the global interrelationships for present and future consequences.

6. I have formed that a key role of the teacher in implementing design and problem solving is to (1) insure that student experience some failure, (2) make sure the student benefits (learns) from that failure, and (3) use these experiences to encourage students to take risks in their design and problem solving. T.E. is one of the few subjects that can make failure a positive part of the student’s learning. We should make good use of these potential.

The design approach to TE also sets the stage for students to rethink what they know (and are learning about a topic/subject/concept as student test their designs the will use their knowledge differently. For example, they will apply science concepts to real problems, rather than just ingest/memorize facts and figures as the student test and improve their designs, they can be helped to see if their concepts of science are accurate or if it is appropriate to revamp/reconstruct their conceptual model(s) of the science concept/principle

7. (about appropriate instructional strategies for problem solving in technology education) Problem solving is an instructional strategy as are these...
(about appropriate proportion of problem solving activity to be included in a technology education) Depends on your definition, 50%-100%

8. Again, "problem-solving" has so many definitions, and it is not defined here, that it doesn't appear to be a useful term to describe what students should be doing in technology education.

When students complete their experiences in our field, ideally, they should be able to look around them and see both what technology has given us and what it has taken away; they should be capable of asking the right questions about the appropriateness of specific technologies in their lives; they should know something of the hows and whys of modern technology and have perspective on the changes these developments have made in the lives of people. Our goal, essentially, is to make people be both appreciative and wary of technology, because it is only in this way that they can control it (instead of the other way around). In order to do this, it is essential for students to become independent thinkers, be able to weigh choices, and to be able to transfer what they have learned to new situations throughout their lives.

Memorizing facts and learning tool skills, while educationally defendable, cannot achieve this goal. Learning strategies that enable students to take facts and skills and apply them may take us closer to this goal. By using a rational "design process" as
a sort of road-map to get from an identified problem to a well thought-out solution, students engage in many activities that themselves require study, practice and assessment.
APPENDIX K

Grouping of the definitions of Problem Solving in Technology Education
Done by Wheatley, Mr. Chuck: Doctoral candidacy and Instructor, The Ohio State University, Technology Education Program.

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<td>Process of resolving difficulties or dilemmas</td>
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<td>6, 7</td>
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<td>Design or use of design process</td>
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<td>Use or application of thought process or intellectual activity or resources</td>
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